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# National Assessment of the Urban Particulate Problem. Volume IX Oklahoma City, Oklahoma

GCA Corp, Bedford, Mass GCA Technology Div

Prepared for

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# NATIONAL ASSESSMENT OF THE URBAN PARTICULATE PROBLEM

## Volume IX - Oklahoma City

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Research Triangle Park, North Carolina 27711

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# National Assessment of the Urban Particulate Problem: Volume IX - Oklahoma City

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This document is one volume of a sixteen-volume report presenting an overall assessment of the particulate problem, which was conducted by GCA/Technology Division for EPA.

This particular document is one of fourteen single-area volumes that provide working summaries of data gathered in the fourteen urban areas studied. These city reports primarily provide documentation and background information for Volume I of the study - National Assessment of the Particulate Problem - Final Report. Volume I should be considered the primary output of the report.

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# NATIONAL ASSESSMENT OF THE URBAN PARTICULATE PROBLEM

*Volume IX*
*Oklahoma City, Oklahoma*

FINAL REPORT

by

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Becky S. Epstein
Frank Record, Project Director

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Contract No. 68-02-1376, Task Order No. 18

EPA Project Officer: Thompson G. Pace

Prepared for

ENVIRONMENTAL PROTECTION AGENCY
Office of Air and Waste Management
Office of Air Quality Planning and Standards
Research Triangle Park, North Carolina 27711

June 1976

This final report was furnished to the Environmental Protection Agency by the OCA/Technology Division in fulfillment of the requirements under Contract No. 68-02-1376, Task Order No. 18. The contents of this report are reproduced herein as received from the contractor. The opinions, findings, and conclusions are those of the authors and not necessarily those of the Environmental Protection Agency.

# FOREWORD

This document is part of a 16-volume report assessing the urban particulate problem, which was conducted by GCA/Technology Division for EPA.

This particular document is one of the 14 single city volumes that provide working summaries of data gathered in the 14 urban areas during 1974 to support an assessment of the general nature and extent of the TSP problem nationwide. No attempt was made to perform detailed or extensive analyses in each urban area. Rather, the city reports are intended as a collection of pertinent data which collectively form a profile of each urban area. This, in turn contributes to a comparative analysis of data among the 14 areas in an attempt to identify general patterns and factors relating to attainment of the TSP problem nationwide. Such an analysis has been made in Volume I of the study-National Assessment of the Urban Particulate Problem-National Assessment. The reader is referred to this volume as the summary document where the data is collectively analyzed.

This and the other 13 city reports are viewed primarily as working documents; thus, no effort was made to incorporate all the reviewer's comments into the text of the report. The comments were, however, considered during the preparation of Volume I and are included herein in order to alert the reader to different points of view. The 16 volumes comprising the overall study are as follows:

| | |
|---|---|
| Volume | I - National Assessment of the Urban Particulate Problem |
| Volume | II - Particle Characterization |
| Volume | III - Denver |
| Volume | IV - Birmingham |
| Volume | V - Baltimore |
| Volume | VI - Philadelphia |
| Volume | VII - Chattanooga |
| Volume | IX - Oklahoma City |
| Volume | X - Seattle |
| Volume | XI - Cincinnati |
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## ACKNOWLEDGMENTS

GCA/Technology Division wishes to sincerely thank those persons and organizations who made significant contributions to this effort. On-going project supervision was provided by Thompson G. Pace of EPA's Control Programs Development Division. The case study in Oklahoma City was greatly assisted by the cooperation and helpfulness of John Gallion and the staff of the State Air Pollution Control Division, and of Ben Cramer and the staff of the Oklahoma City-County Health Department.

## EXECUTIVE SUMMARY

Oklahoma City is an institutional, light-industrial city located in slightly rolling hills in the center of Oklahoma. The major fuel is natural gas, and the biggest industrial categories are electric equipment manufacturers and food and agriculture products. Climatology is that of the Great Plains, with hot summers and moderate winters, consistently high wind speeds, and relatively light precipitation.

### SOURCES AND EMISSIONS

Inventoried emissions from conventional sources are about 6,500 tons per year, primarily from area source fuel use and transportation, including a large aircraft contribution. Emissions from fugitive dust sources, though not at all as well estimated, are certainly comparable and probably much greater in magnitude.

### METEOROLOGY AND CLIMATOLOGY

Oklahoma City climatology is typical of the southern Great Plains. Precipitation is light (averaging 31 inches per year), but 1973 and 1976 had 42 and 39 inches, respectively. Winds are generally high, 12 to 15 mph, and are typically south-southeast except in winter, when northerly winds prevail. Thunderstorms are frequent, and "dust storm" type conditions occur, although air quality data representing the latter are discounted.

## REGULATIONS

Essentially similar regulations are enforced by both the state and city-county agencies. Incinerator, process weight, and fuel combustion regulations are moderate to weak in stringency, as is perhaps consistent with the relative contribution from such sources.

## URBAN ACTIVITY

A quantitative analysis of general traffic versus TSP was not possible, but some sites have a clear influence from vehicular emissions and re-entrainment. There has been a major downtown urban renewal project, involving extensive demolition over the last 5 years. This has clearly influenced levels at nearby sites, although a quantitative separation of this effect has not yet been possible.

## IMPLEMENTATION PLANNING

The Oklahoma SIP has been reviewed and revised twice since its original submission, updating air quality information and revising calculations. Adequate air quality data has been utilized, although levels believed due to "dust storm" conditions have been deleted. Standard proportional modeling has been used, but the lack of a complete emissions total has made quantitative planning difficult.

## CONCLUSIONS

Of the five sites where the primary standard has not yet been achieved, one is because of significant traffic exposure, another because of adjacent construction, and the other three, in the center city, because of CBD traffic and urban renewal activity. The most appropriate action for improvement in air quality is the estimation of emissions from, and the development of control approaches for urban sources of fugitive dust.

## REVIEWERS' COMMENTS

The draft report for each city was submitted to interested EPA, state, and local officials for comment on the contents and findings. Comments of an editorial nature were reconciled; comments of a substantive nature which reflect differences of opinion were compiled and are presented below.

With respect to a data analysis that is cited on page 19, of which the purpose is to "quantifiably separate the effects of the urban renewal effort from the effects of other center city activity," it would be helpful if further details were given concerning the methodology of the data analysis.

It was pointed out in the conclusions that there appeared to be a relationship between precipitation patterns and TSP levels. The report goes on to suggest that the "continued maintenance of ambient standards at these sites is probably dependent on precipitation patterns." In order to test the degree of association between precipitation and particulate levels, we suggest that the contractor perform a correlation analysis and, in particular, develops a correlation coefficient for these two variables on both an annual and a monthly basis.

It was also indicated in the conclusions that the particulate measurements at five monitoring sites did not meet the primary standards. The explanations that the contractor offered for these violations appeared to be reasonable. We recommend, however, that the contractor perform an analysis to substantiate these suppositions.

Another comment is concerned with a statement in the conclusions which reported that the regulations imposed on point source emissions in the Oklahoma City area are moderate to weak in stringency. The statement goes on to emphasize that the relative contributions from these sources is nominal when compared to the overall particulate situation, and, therefore, "it seems very unlikely that further emission reductions would be the most effective way with which to improve particulate air quality."

Nevertheless, EPA policy asserts that point source emissions are significant and that their effects should not be minimized. The EPA has established emission limitation regulations for point sources such as best available control technology and new source performance standards. In addition, it should be recognized that certain particulate emissions from stationary sources are responsible for deleterious health effects.

It is not clear from the data on page 4 whether or not the 24 hour NAAQS was actually violated, since it takes two excursions over the standard to record a violation.

It is not clear whether dust storm days were removed from the data.

The data for annual means are annual geometric means.

The inventory estimate of area sources in Tables 6 and 7 was made circa 1970 and was not independently verified.

# SECTION I

# INTRODUCTION

## NATURE OF THE OKLAHOMA CITY AREA

The Central Oklahoma AQCR consists of nine counties in the center of the state, centered about Oklahoma County and Oklahoma City, the State capital (see Figure 1). Oklahoma City is set in gently rolling countryside; its elevation is around 1250 feet above mean sea level, and the nearest significant hills are the Arbuckles, 80 miles south. The North Canadian River runs through the city, though it is often nearly dry.

Although some influence is exerted at times by warm, moist air currents from the Gulf of Mexico, the climate of the Oklahoma City area falls mainly under continental controls characteristic of the Great Plains Region. The continental effect produces pronounced daily and seasonal temperature changes and considerable variation in seasonal and annual precipitation. Summers are usually hot, but discomfort is moderated by low humidity and the prevalence of a moderate breeze. Winters are comparatively mild and short, with little snow and only moderate heating demand.

The Oklahoma City area receives less precipitation than is typical of the northeastern portion of the country, but is fairly well vegetated and is not truly arid. Precipitation comes primarily in the spring and summer, much of it in occasional heavy thunderstorms. Wind speeds are generally high, averaging 12 to 15 miles per hour. There is a generally prevailing flow from the south, except during January and February when northerly breezes predominate.

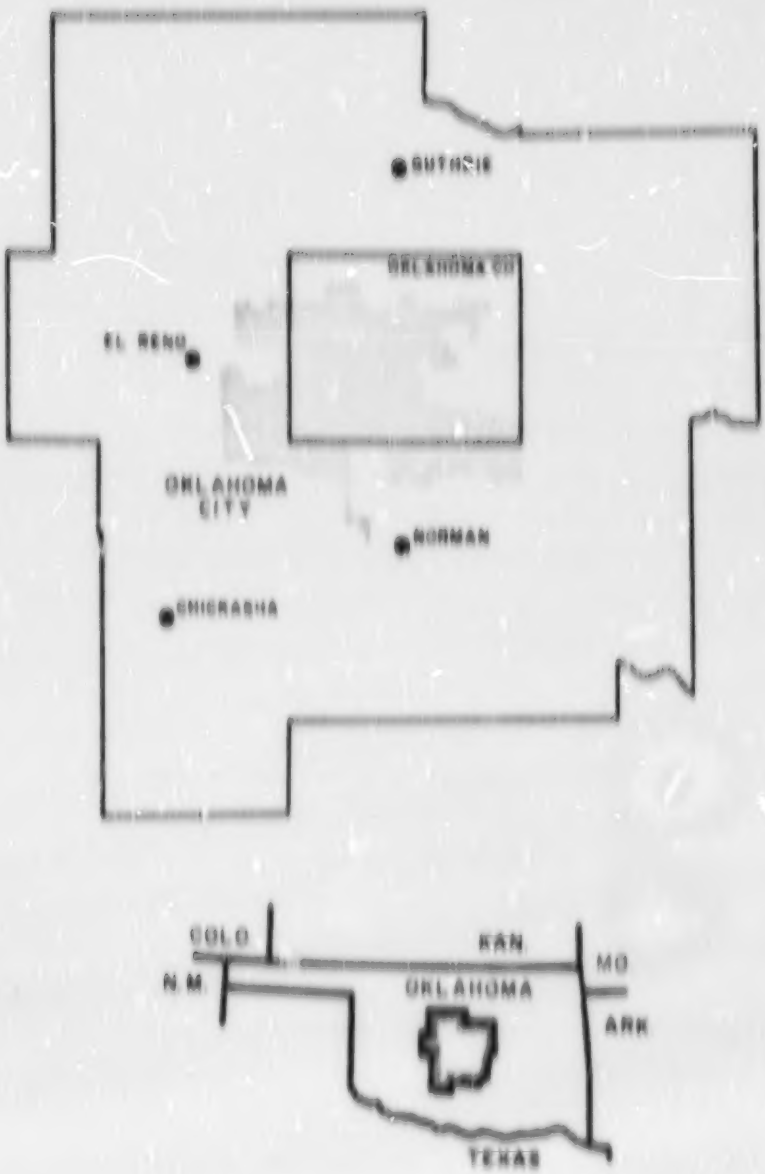



Figure 1. Location of Central Oklahoma AQCR and Oklahoma City and County

Economically, Oklahoma City is primarily an institutional city rather than a manufacturing center. The 1970 population of the city was 366,734 (579 per square mile), an increase of 13.6 percent since 1960. Approximately 30 percent of the population is employed in government. Services, retail trade, and manufacturing are the other large employers -- each with over 10 percent of the employees of the city (see Table 1). The electrical equipment industry employs 18 percent of the manufacturing work force, and 36 percent is employed by the food processing, machinery and transportation equipment industries.

Table 1. EMPLOYMENT IN OKLAHOMA CITY

| Category | Number of employees | Percent of total |
|---|---|---|
| Agricultural services forestry, fisheries | 1,000 | < 1 |
| Mining | 7,000 | 2 |
| Contract construction | 19,000 | 6 |
| Manufacturing | 44,000 | 13 |
| Transportation and other public utilities | 14,000 | 4 |
| Wholesale | 19,000 | 6 |
| Retail | 56,000 | 17 |
| Finance, insurance and real estate | 20,000 | 6 |
| Services | 47,000 | 14 |
| Government | 99,000 | 30 |
| Total | 331,000 | 100 |

Source: "County Business Patterns (1973)"

A comprehensive state-local pollution control program is conducted by the Oklahoma City-County Health Department and the Air Quality Service of the Oklahoma State Department of Health, which is also located in Oklahoma City.

## AIR QUALITY PATTERNS AND TRENDS

The Oklahoma City-County Health Department operates a network of monitoring sites for particulates within Oklahoma County. Complete data is available on 1974 particulate levels from 14 of these hi-vol sites in the Oklahoma City vicinity (see Figure 3). They are distributed geographically throughout the city and its environs and are located in areas of differing land use. There is no truly industrial site, however, because there is no clearly concentrated heavy industrial district in Oklahoma City.

During 1974, five of these sites had levels above the primary standard, one was above the secondary standard, and the other eight sites had TSP levels below 60 $\mu g/m^3$ (see Table 2 and Figure 3). The five sites not attaining the primary standard include three (Nos. 15, 17, 22) of the four located in the central business area, one (No. 18) that is fairly central and subject to heavy traffic, and one suburban site (No. 14) subject to the influence of immediately local construction.

Most sites did not record violations of the 24-hour primary standard in 1974. The five sites that did, recorded violations for 3 percent or less of the sampling periods (Table 2), the most frequent being violations at site 15 in the CBD. There are violations of the 24-hour secondary standard at almost all sites; only one rural site, No. 5 in Jones, recorded no violations at all. Two sites in the center city area have violations of the 24-hour secondary standard on 13 and 15 percent of the sampling days in 1974. Three other sites - two in suburban areas and one in the center city area - record violations of the secondary standard over 5 percent of the time; the rest of the sites had few violations during the year.

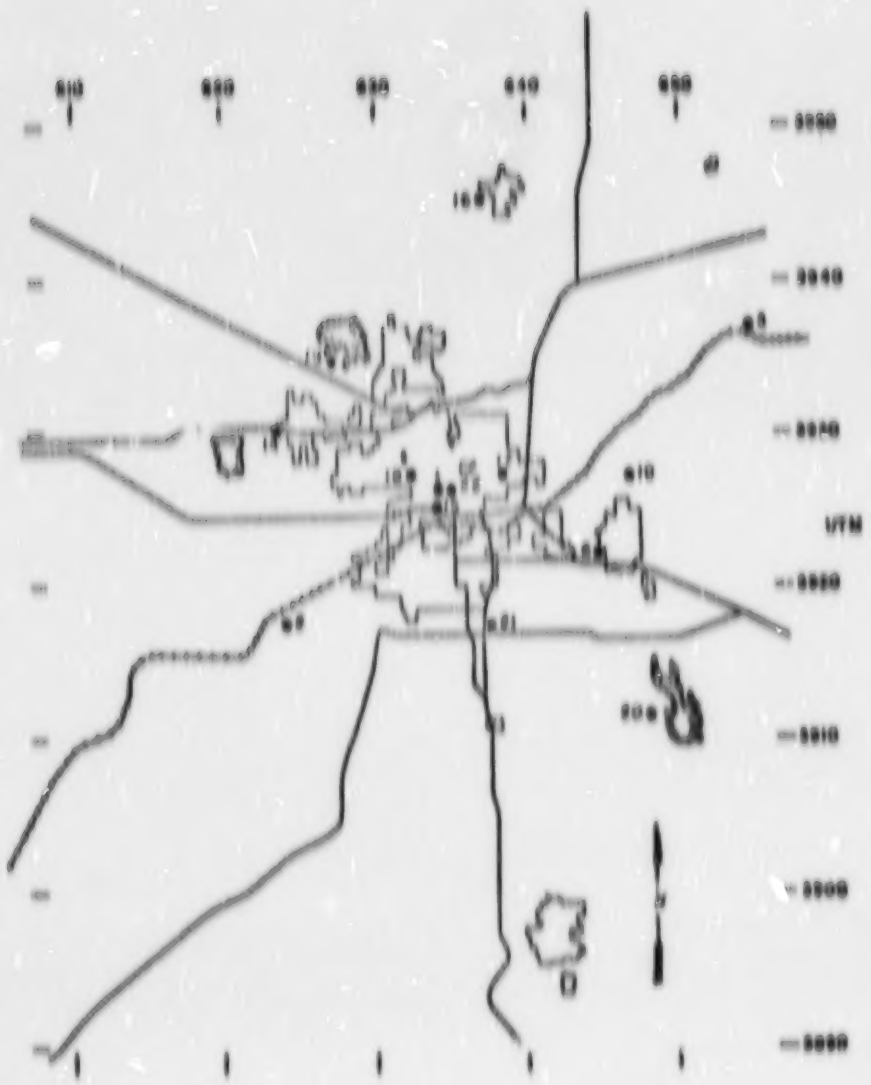


Figure 2. Locations of monitoring sites in Oklahoma City

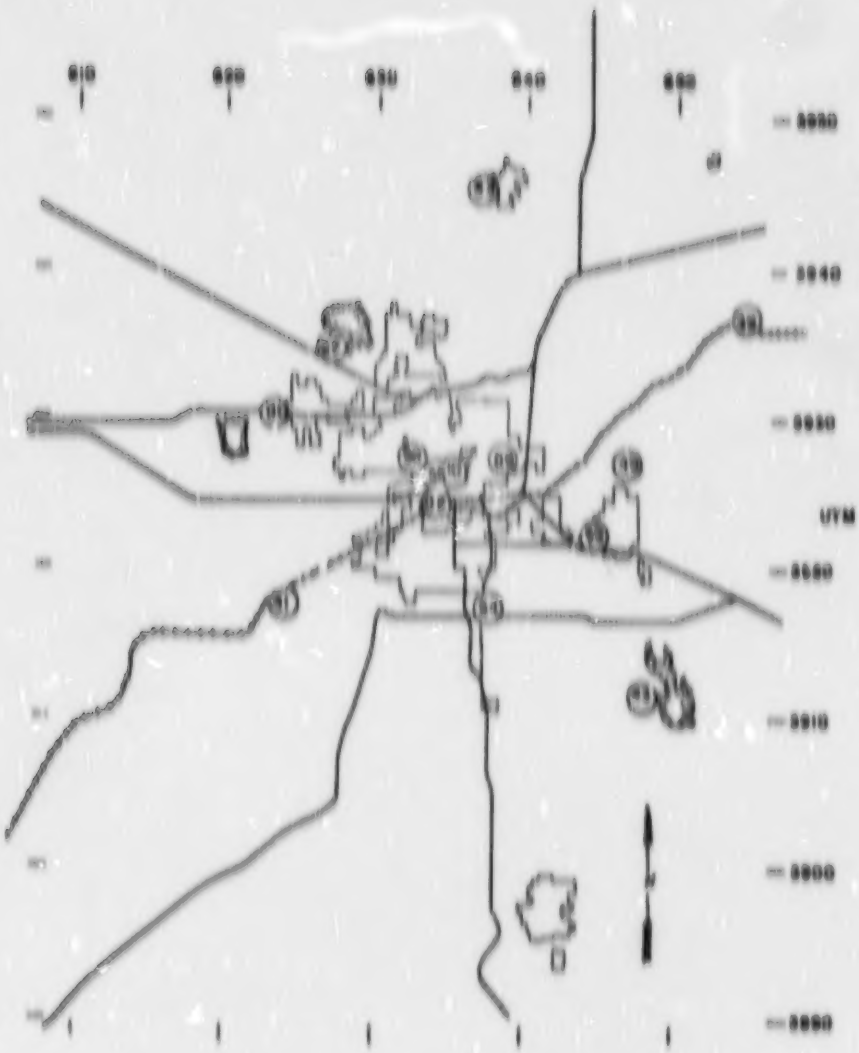


Figure 3. 1974 mean TSP concentrations ($\mu g/m^3$) at monitoring sites

Table 2. AIR QUALITY SUMMARY

| Site No. | Site characteristic | 1974 geometric mean TSP, $\mu g/m^3$ | Frequency of violation of 24 hour standards, percent | |
|---|---|---|---|---|
| | | | Primary | Secondary |
| 22 | Center city | 107 | 1 | 15 |
| 18 | Center city | 96 | 2 | 7 |
| 15 | Center city | 92 | 3 | 13 |
| 17 | Suburban | 89 | 0 | 6 |
| 14 | Suburban | 80 | 0 | 9 |
| 19 | Suburban | 62 | 0 | 1 |
| 6 | Suburban | 59 | 0 | 3 |
| 1 | Center city | 55 | 2 | 2 |
| 21 | Suburban | 54 | 1 | 3 |
| 16 | Suburban | 53 | 0 | 1 |
| 10 | Suburban | 49 | 0 | 3 |
| 20 | Rural-agricultural | 43 | 0 | 2 |
| 2 | Rural-agricultural | 41 | 0 | 1 |
| 5 | Rural-agricultural | 39 | 0 | 0 |

Trends in TSP Levels

The current sampling network in Oklahoma City was established in 1972, so there is almost no data available on historical air quality trends. An NASN site had been sampling since 1964 at site 22 until it was moved a few blocks away to site 15 in 1972. The continuous data available for about 8 years at site 22 (Figure 4) shows a general decrease in TSP levels. There is a dip in 1967-1969, a rise in 1970-1971, and the beginning of another dip during 1972. The few extremely high readings over the years are apparently the result of dust storm-like conditions of very low precipitation and high winds.

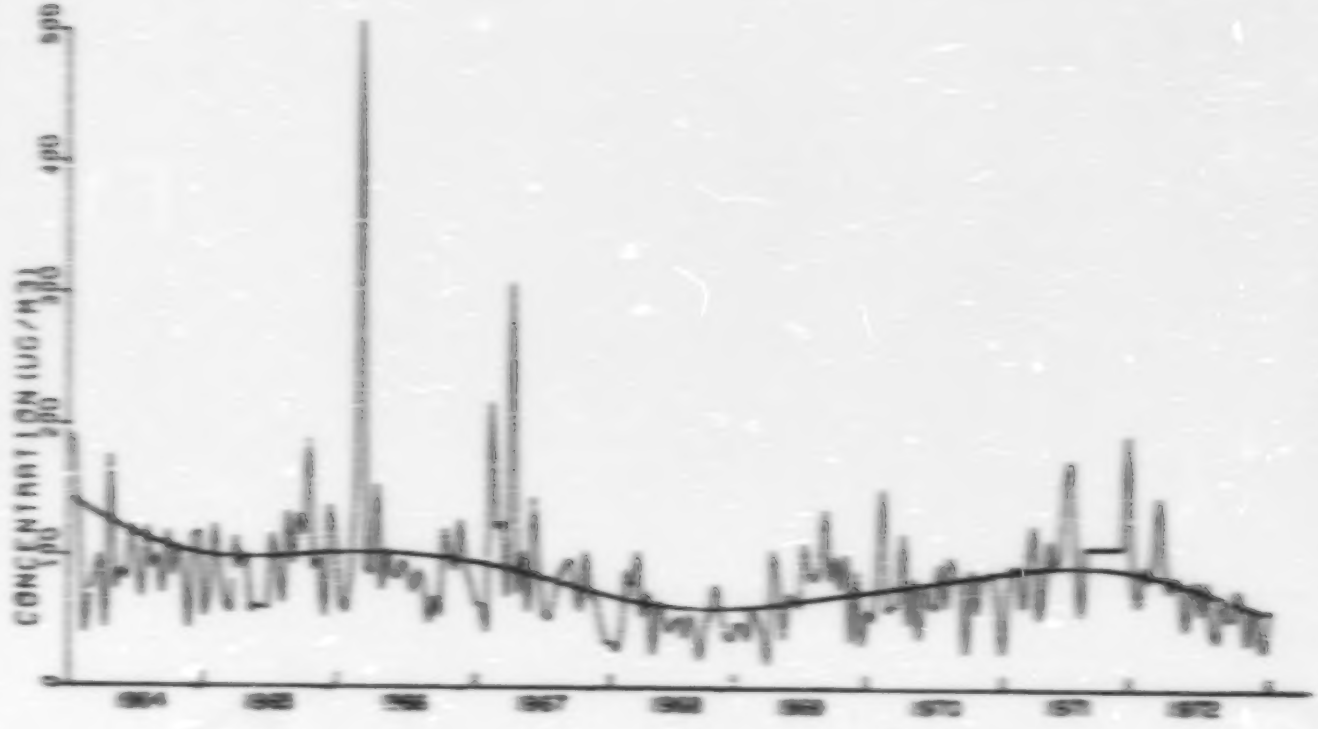


Figure 4. Long-term trend at [illegible] site

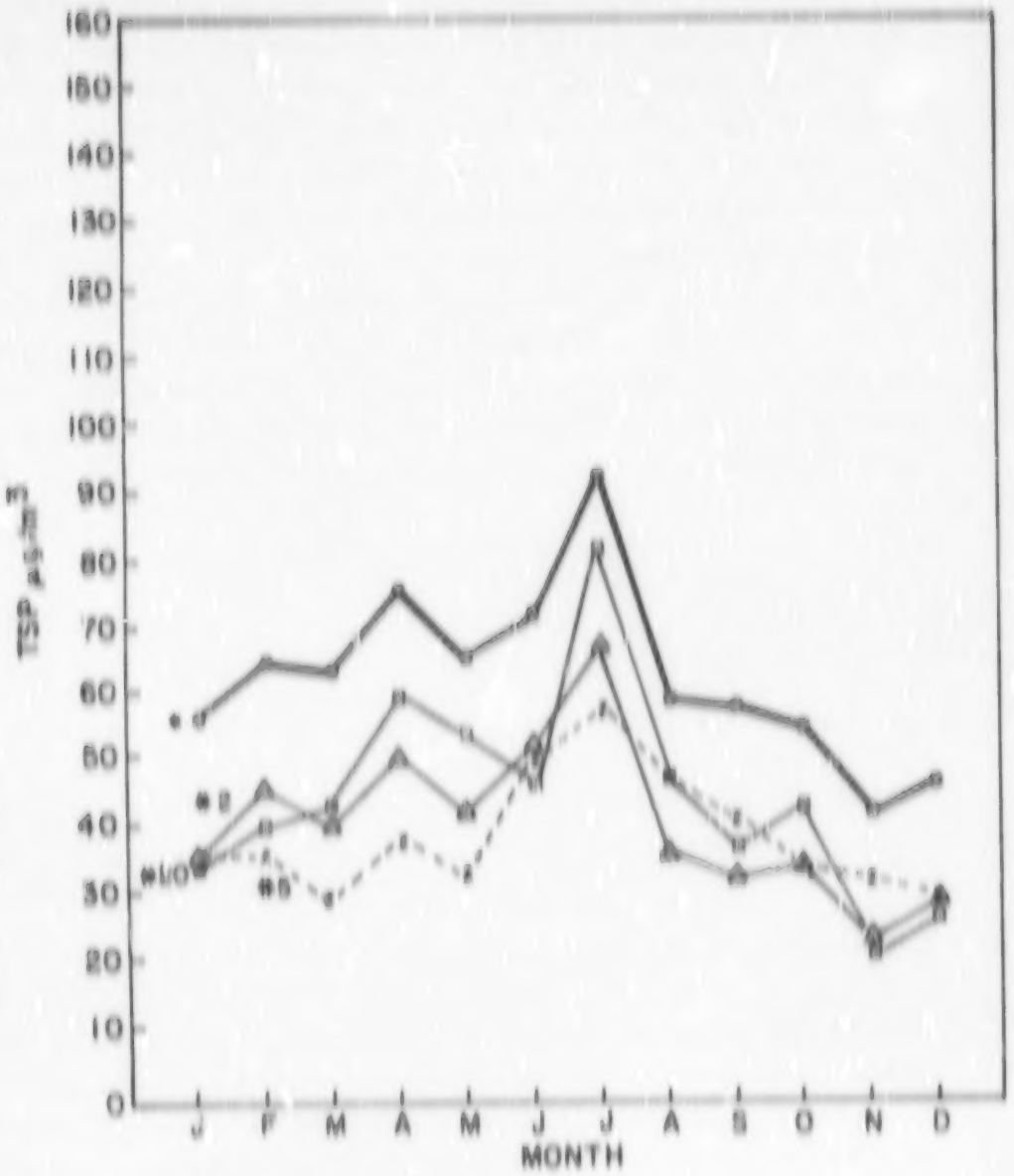
Citywide TSP levels have been in the low 60's from 1972 to 1974. The TSP levels for the 3 years are tabulated in Table 3 in groups according to land use. Center city levels have clearly been the highest, ranging from 86 to 99 $\mu g/m^3$; the composite trend, which is slightly downward, is a mixture of much more striking trends at the individual sites. Sites 22 and 1, the highest and lowest CBD sites, respectively, both had dramatic decreases over the 3-year period, while sites 15, 17, and 18 increased noticably between 1972 and 1973, and then decreased again in 1974. The composite trend of the suburban sites increases over the period; this is primarily the result of striking changes at site 19 and especially site 14. The three rural agricultural sites all show a very similar trend, decreasing in 1973 and then increasing again in 1974.

Table 3. TSP TRENDS ACCORDING TO LAND USE

| Site characteristic | Site numbers | Annual mean TSP, $\mu g/m^3$ | | |
|---|---|---|---|---|
| | | 1972 | 1973 | 1974 |
| Center city-commercial | 1,15,17,18,22 | 98.8 | 96.7 | 86.4 |
| Suburban | 6,10,14,16,19,21 | 54.1 | 57.4 | 58.2 |
| Rural-agricultural | 2,5,20 | 43.0 | 38.0 | 40.2 |
| Yearly average | All sites | 65.3 | 64.0 | 61.6 |

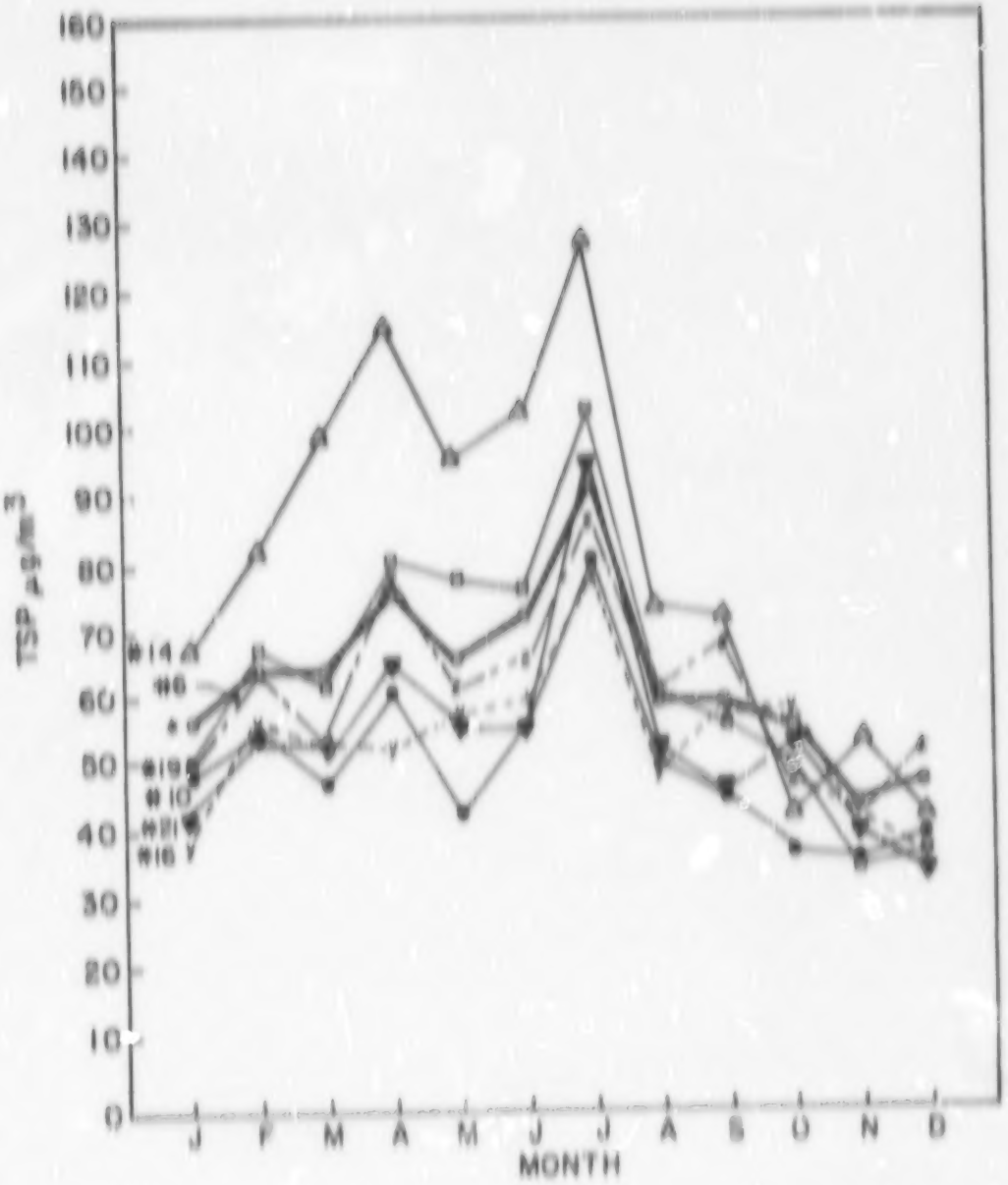
Seasonal Patterns of TSP Levels

Because the monitoring network in Oklahoma City operates on an every-3-days sampling cycle, reliable monthly means and seasonal patterns can be expected. Figures 5, 6, and 7 present the 1974 seasonal patterns for the three groups of sites that were listed in Table 3; the combined pattern for the entire network is also plotted in each of the three figures. In Figure 5 it is apparent that the three outlying sites exhibit generally the same seasonal pattern, and that the overall network average also follows a similar pattern. At the suburban sites (Figure 6) most of the sites also follow the typical pattern, with



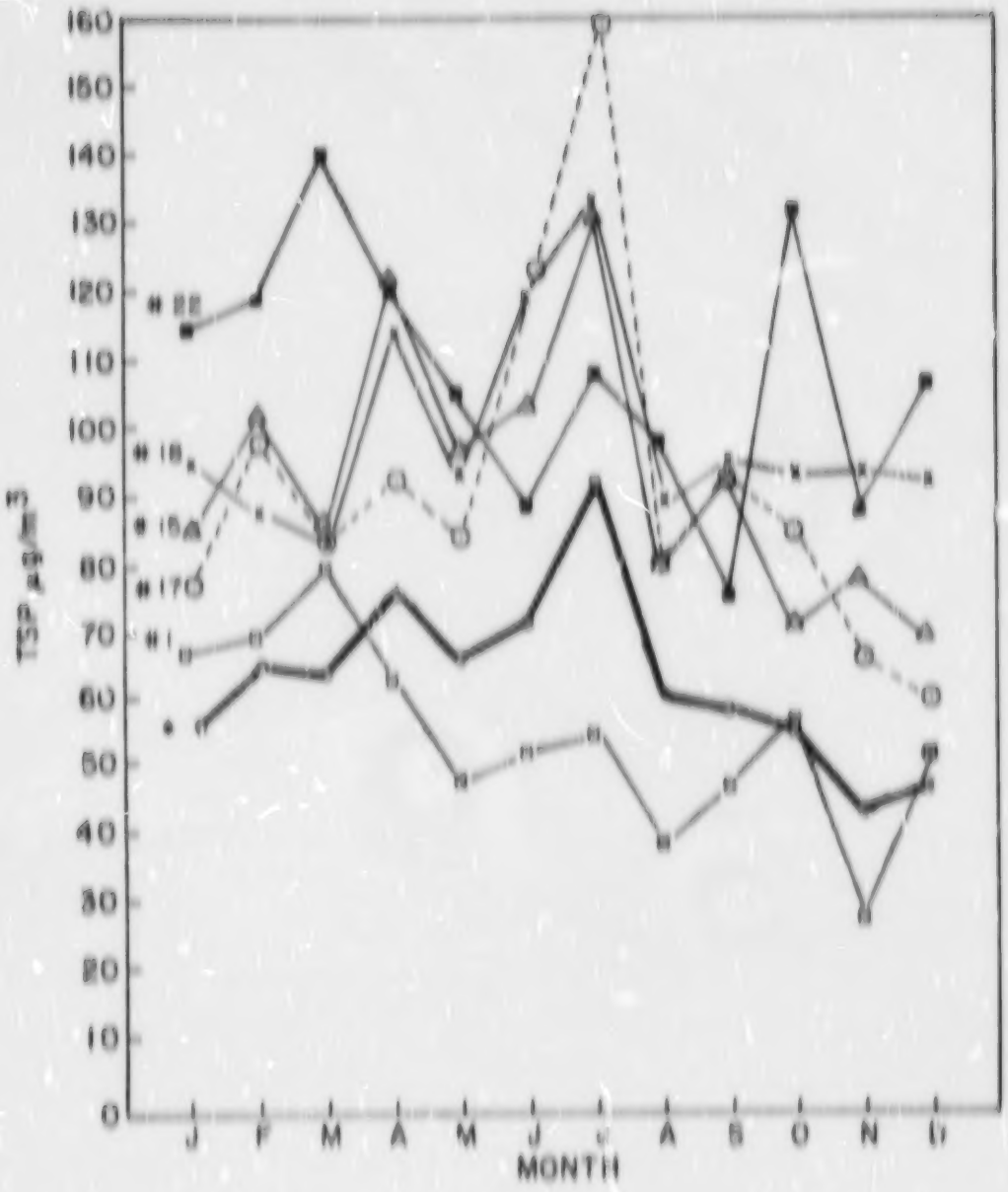

*Mean for all sites in county.

Figure 5. Seasonal pattern at rural-agricultural sites in 1974




*Mean for all sites in county.

Figure 6. Seasonal pattern at suburban sites in 1974




*Mean for all sites in county.

Figure 7. Seasonal pattern at center city-commercial sites in 1974

relative maxima in February, April, and July. Site 14, however, while following the general shape of the pattern, exhibits a clear elevation in levels for the first two-thirds of the year, falling back into general agreement with the bulk of sites by September or October.

The seasonal patterns at the center city sites (Figure 7) are less consistent with each other and the overall average pattern. Site 1, the only center city site meeting the primary standard, is clearly lower than the others, and shows a much less distinct July peak than any of the other sites in the network. The April peak, consistent throughout the rest of the network, is clear at three of the center city sites, but not at all at sites 22 and 1. These two sites (22 and 1) are located fairly close together and generally track each other quite well; both show clear peaks in October, for instance. It appears that the primary influence causing most of the departures from the common pattern is the existence of very local influences, especially building demolition and construction; we will return to this subsequently.

## SECTION II

## ANALYSES

This section considers in turn the factors that likely influence particulate levels and the attainment of standards in Oklahoma City, providing relevant information and presenting the analyses that have been undertaken to assess the significance of the various factors. The following issues are considered in turn in the following text: sources and emissions, meteorology and climatology, regulations and control, network design and siting, urban activity, and implementation planning procedures.

### SOURCES AND EMISSIONS

Oklahoma City is a generally light industrial area, and the dominant fuel is natural gas; consequently, emissions from traditional pollution sources are relatively small. The most recent estimates of emissions in the AQCR total about 6500 tons per year, mostly from area sources. As is found in other areas as well, however, there is some degree of inconsistency among estimates made by various sources at various times. Table 4 presents a complete emissions inventory compiled to represent the best current estimate available to the Oklahoma State agency. The 5231 tons per year area-source portion is based on a 1970 inventory developed for SIP planning in 1972; the point source figures are based on the most recent NEDS update, completed by the state agency in mid-1974, which is summarized in Table 5.

Table 4. CURRENT EMISSIONS ESTIMATES BY SOURCE CATEGORY

| Source type | Point sources | Area sources |
|---|---|---|
| Fuel combustion | | |
| Residential | | |
| • Distillate oil | | 23 |
| • Natural gas | | 232 |
| Commercial/institutional/industrial | | |
| • Distillate oil | 12 | 127 |
| • Residual oil | 0 | 66 |
| • Natural gas | 29 | 286 |
| • Liquid petroleum gas | 0 | 363 |
| Electric generation | | |
| • Bituminous coal | 17 | |
| • Distillate oil | 125 | |
| • Residual oil | 0 | |
| • Natural gas | 388 | |
| Process losses | | |
| Food and agriculture | 313 | |
| Mineral products | 402 | |
| Other manufacturing | 78 | |
| Refuse disposal | | |
| Open burning | | 0 |
| Transportation | | |
| Gasoline vehicles | | 1113 |
| Aircraft | | 2359 |
| Other | | 462 |
| | 1264 | 5231 |
| Total point and area sources | | 6495 |

Table 5. POINT SOURCE INVENTORY -- CENTRAL OKLAHOMA AQCR

| Source type | Emissions, tons/year | | |
|---|---|---|---|
| | Process loss | Fuel use | Total |
| **Oklahoma County** | | | |
| Feed manufacturing | 174 | | 174 |
| Feed manufacturing | 78 | 18 | 96 |
| Mineral processing | 90 | | 90 |
| Electrical manufacturing | 57 | | 57 |
| Asphalt plant | 32 | | 32 |
| Asphalt plant | 32 | | 32 |
| Asphalt plant | 31 | | 31 |
| Asphalt plant | 29 | | 29 |
| Asphalt plant | 25 | | 25 |
| Feed manufacturing | 22 | | 22 |
| Asphalt plant | 19 | | 19 |
| Metal processing | 15 | | 15 |
| Brick manufacturing | 13 | | 13 |
| Power plant | | 9 | 9 |
| Brick manufacturing | 9 | | 9 |
| Asphalt plant | 8 | | 8 |
| Asphalt plant | 8 | | 8 |
| Tire manufacturing | 1 | 6 | 7 |
| Metal processing | 5 | | 5 |
| Food/agriculture | 4 | | 4 |
| Petroleum | | 3 | 3 |
| Subtotal - Oklahoma Co. | 652 | 36 | 688 |
| **Outside Oklahoma County** | | | |
| Power plant | | 223 | 223 |
| Power plant | | 198 | 198 |
| Asphalt roofing | 49 | 10 | 59 |
| Asphalt plant | 50 | | 50 |
| Feed manufacture | 20 | | 20 |
| Feed manufacture | 15 | | 15 |
| Asphalt plant | 5 | | 5 |
| Petroleum | | 4 | 4 |
| Brick manufacture | 2 | | 2 |
| Subtotal - outside Oklahoma Co. | 141 | 435 | 576 |
| Total | 793 | 471 | 1264 |

As indicated in Table 4, the largest point source emissions are from industrial processes, primarily feed manufacturing and asphalt batching, and from the electric generating plants, the largest of which are outside the immediate Oklahoma City-County area.

The bulk of the total inventory, however, is from area sources, with the major categories being aircraft, gasoline vehicles, and commercial/institutional/industrial fuel use, in that order. The details underlying these area source estimates were not available, but it appears that conventional inventory techniques and emission factors were used, and that the transportation categories represent only tailpipe, etc., emissions, as opposed to street or road dust entrainment. The high contribution from aircraft is probably realistic; it represents operations not only at Will Rogers World Airport, the regional civilian field, but also at Tinker Air Force Base, a major military facility. The entire area source portion of the inventory has not been updated recently; thus, it is likely that some contributions have changed somewhat.

Of greater concern for the accurate assessment of particulate problems in the Oklahoma City area are the fugitive-dust area sources, that is, particulate emissions from open area sources of entrained particulates such as agricultural areas and construction sites. Both of these two examples are readily apparent problems in the Oklahoma City area, as are vehicle-entrained emissions from the yards and grounds of the area's asphalt and concrete batching plants. In a more general sense, the historical memories of the depression era "dust bowls" are a reminder that wind and precipitation patterns can be highly significant in the area.

Traditionally, the air pollution community has not utilized quantitative estimates of emissions from this type of source in air quality planning, and the Oklahoma City area is no exception. Recently, EPA contract efforts have provided estimates of emissions from several fugitive dust sources; the estimates for the Oklahoma City area are presented in Table 6. The

figures in Table 6 amount to hundreds of thousands of tons per year. Obviously, if these figures are even only roughly correct, sources such as traffic on unpaved roads and open construction sites, especially the former, will totally dominate the particulate situation in the area; however, it is not at all yet clear that these estimates should be regarded as valid in this context. The estimates in Table 6 are part of a study aimed at providing county-by-county estimates for the entire country; as such, it involved data base selections and estimation procedures that are not necessarily appropriate for urban or near-urban counties. In general, based on similar estimates in more heavily industrialized areas, the results do in fact seem to be very high; it is apparent, however, that even if they were erroneously high by a factor of 100, this type of particulate source would still be of major significance in comparison with the 6500 tons per year from traditional sources.

Table 6. FUGITIVE SOURCE EMISSIONS ESTIMATES

| | Emissions, tons/year | |
|---|---|---|
| Source | Oklahoma County | Central Oklahoma AQCR |
| Unpaved roads | 85,920 | 708,393 |
| Dirt air strips | 0 | 0 |
| Construction | 85,140 | 142,631 |
| Land filling | 1,540 | 30,330 |
| Total | 172,600 | 863,354 |

## Trends in Emissions

As in other areas, information on changes in emissions over time is relatively scanty. Table 7 presents the emissions inventory utilized in implementation planning, designed to represent emissions in 1970; the data is compiled in such a format as to be comparable to the current estimated presented in Table 4. The total estimate has changed from 15,399 to 6,495 tons per year, a reduction of 8,904 tons per year, or

Table 7. 1970 EMISSIONS AS ESTIMATED FOR SIP

| Source type | Point sources | Area sources |
|---|---|---|
| Fuel combustion | | |
| Residential | | |
| • Distillate oil | | 23 |
| • Natural gas | | 232 |
| Commercial/institutional/industrial | | |
| • Distillate oil | | 327 |
| • Residual oil | 2 | 66 |
| • Natural gas | 99 | 286 |
| • Liquid petroleum gas | 10 | 363 |
| Electric generation | | |
| • Bituminous coal | 18 | |
| • Distillate oil | 1 | |
| • Residual oil | 4 | |
| • Natural gas | 523 | |
| Process losses | | |
| Food and agriculture | | |
| Mineral products | 7931 | |
| Other manufacturing | | |
| Refuse disposal | | |
| Open burning | | 1580 |
| Transportation | | |
| Gasoline vehicles | | 1113 |
| Aircraft | | 2359 |
| Other | | 462 |
| | 8588 | 6811 |
| Total point and area sources | | 15,399 |

about 58 percent, in the emissions from traditional sources. About one-sixth of this represents the elimination of an estimated 1,580 tons per year of particulate emissions from open burning; the balance is the reduction in point source emissions.

A comparison of the point source emissions estimates in Tables 4 and 7 shows a reduction in each of the three major categories. Emissions from electric power generation decreased 21 percent from 546 to 430 tons per year, even with an apparent significant shift from natural gas to distillate oil, and commercial/institutional/industrial fuel use emissions went from 111 to 41 tons per year. Since the detailed basis of the earlier inventory is not available, it is not clear whether these differences in emissions from point source fuel use are anomalies of the inventory procedures, or represent changes in the heating load and shifts in electric power demand between the two periods. The former is more likely, but in any event the changes do not, of course, represent a major pollution control attack on emissions from fuel combustion, since the use of natural gas precludes fuel combustion from being a significant problem in the first place.

On the other hand, the 90 percent decrease in industrial process loss emissions (from 7,931 to 793 tons per year) does apparently represent the result of efforts to control emissions from process sources. Although the 1970 inventory does not provide a breakdown by industry type within the process loss category, the only significant industrial categories are feed manufacturing and asphalt batching; indications from the state and city-county agencies are that indeed sizable reductions did occur in estimated emissions from these categories, especially the asphalt plants.

With respect to the fugitive dust sources that may represent a significant uninventoried portion of Oklahoma City's particulate burden, it is not presently possible to clearly establish any trends over time,

though such could be readily done once estimation procedures are established. There is indirect evidence, however, to confirm the presumption that the amount of such emissions is sensitive to trends in wind speed and especially in precipitation. Hagen and Woodruff have studied air pollution from dust storms during the 1950's at a number of Great Plains locations, including Oklahoma City. In 1973, they compared these results with similar information from the 1960's, and discovered a roughly tenfold decrease in such entrained particulate matter at most sites; the decrease at Oklahoma City (Will Rogers Field) was 91 percent, from 27.1 to 2.3 tons per vertical square mile. Regardless of the precise significance of Hagen and Woodruff's estimates, this massive change in what may be a major portion of the particulate load suggests the necessity of considering meteorological factors in developing quantitative emission trends.

Geographic Distribution of Sources

In general, the industrial and population-related activities of the AQCR (Figure 1) are centered in the central Oklahoma County; 82 percent of the point source process emissions are in Oklahoma County. In contrast, the vast majority of the fuel use emissions are located outside the central county, in particular the major power plant, which is just to the west of the county line in Canadian County (see Figure 8). It is presumed, though there is no documentation available, that area source fuel use and transportation emissions are similarly concentrated in Oklahoma City and County.

METEOROLOGY AND CLIMATOLOGY

The meteorological factors reviewed as possibly affecting particulate levels in the various urban areas include: rainfall, wind direction and speeds, and temperature. In Oklahoma City, the amount of rainfall and number of days with precipitation have been investigated in

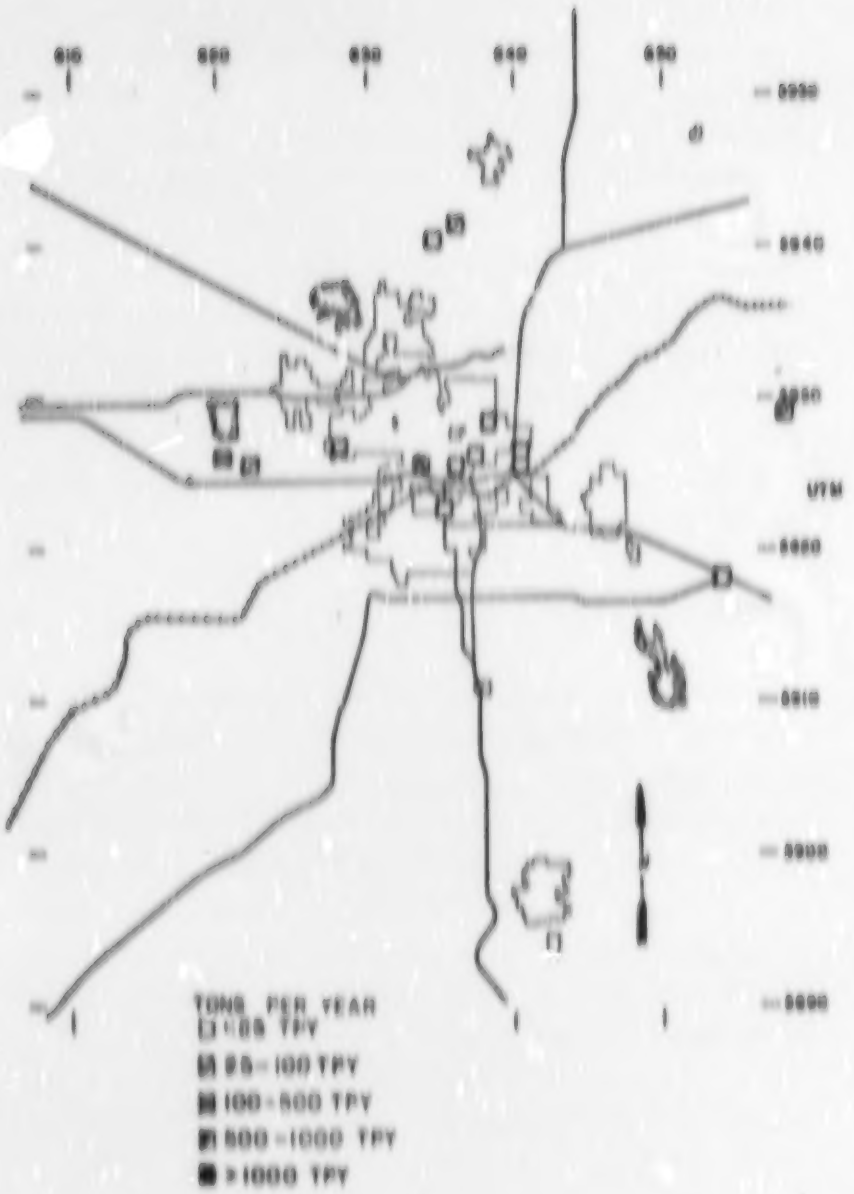



Figure 8. Location of point sources

particular, largely by considering the similarity of the time trends and seasonal patterns of TSP and meteorological variables.

Precipitation

In general, there is only a 3-year period of data available at the hi-vol sites. Average TSP levels for Oklahoma City did decrease between 1972 and 1974, though not far enough, or uniformly enough across the region, as to constitute a significant trend or even a real difference in levels. As seen in Figure 9, rainfall was much heavier than normal in 1973 and 1974, which may well account for the decrease in levels at the rural-agricultural sites and those suburban sites without other specific influences. At the NASN site, where trend data is available from 1964 to 1972, there appears to be a rough correlation between TSP (Figure 4) and annual rainfall -- higher TSP levels during the dry mid-1960's, and lower levels during 1968 and 1970 than in adjacent years. This annual-scale relationship could reflect the longer-term influences of precipitation on changes in vegetation patterns as well as, or perhaps more likely than, the shorter-term impact through the supression of fugitive dust emissions.

Somewhat more obvious relationships can be seen in comparing seasonal patterns of precipitation and particulate levels in 1974. Comparing the seasonal pattern of precipitation in Figures 10 and 11 with TSP patterns in Figures 5, 6, and 7, July stands out clearly with the highest TSP levels during the year and both the lowest amount of rainfall and lowest number of days with precipitation. There is more rainfall in May and a lower average suspended particulate level; rainfall increases in August and September and particulate levels decrease then. The inverse relationship of TSP and rainfall is most evident during the warmer months, suggesting other factors must be more influential in the winter season.

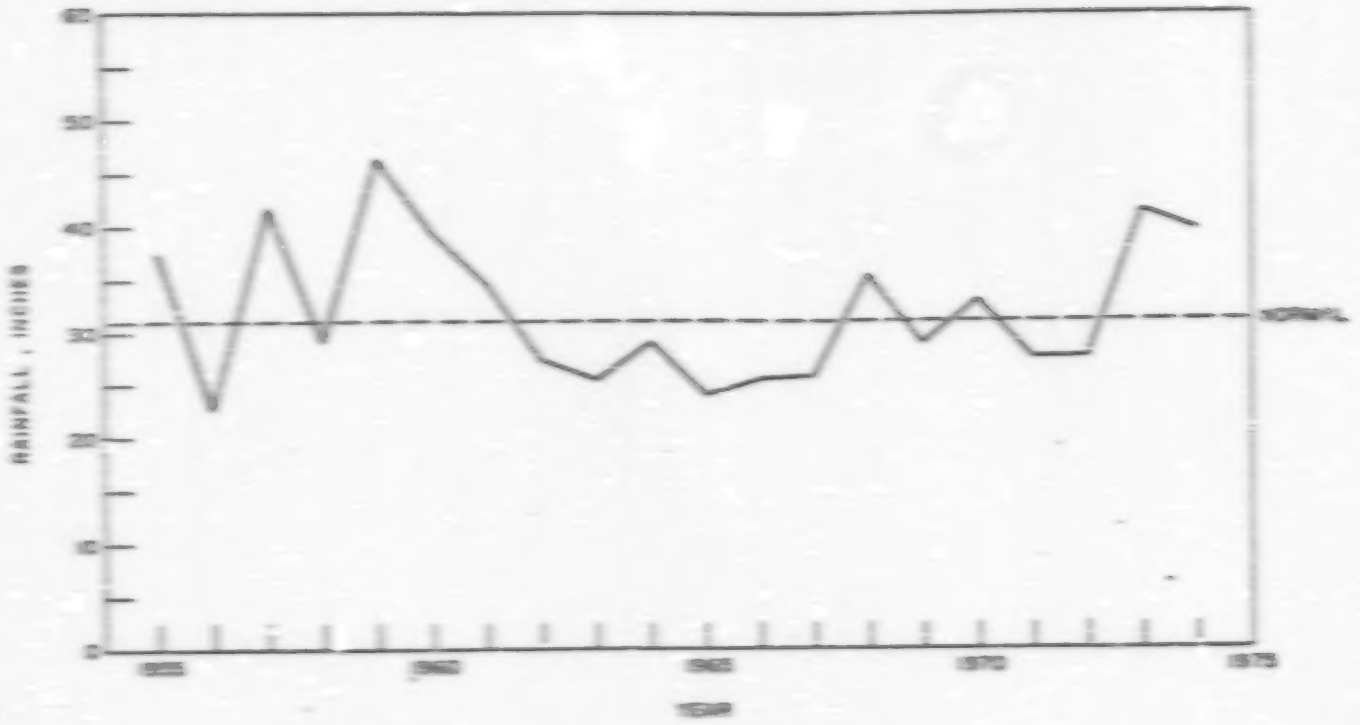



Figure 9. Annual 24 annual rainfall

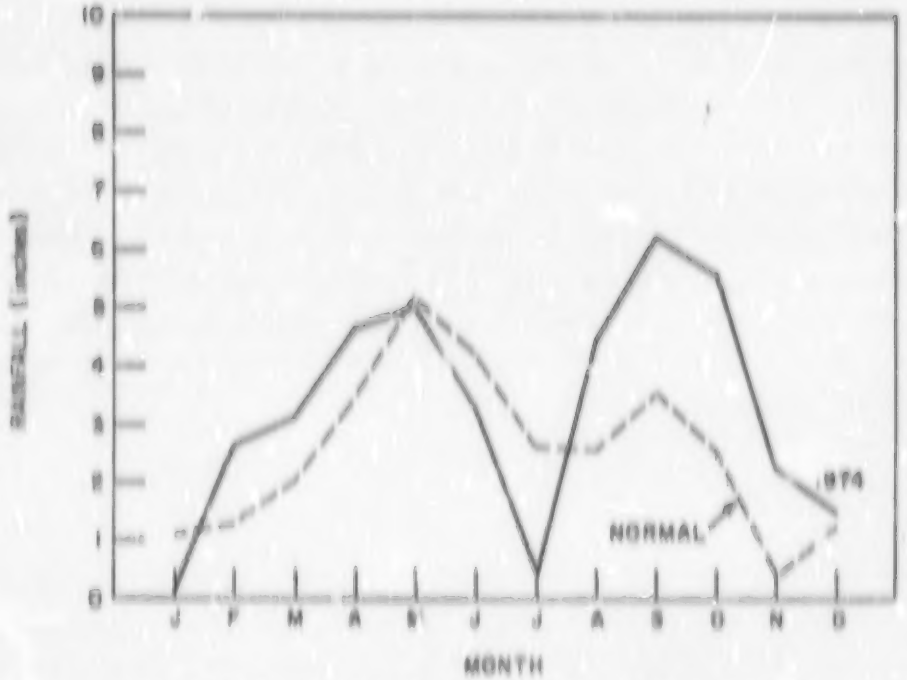



Figure 10. Seasonal pattern of rainfall amounts

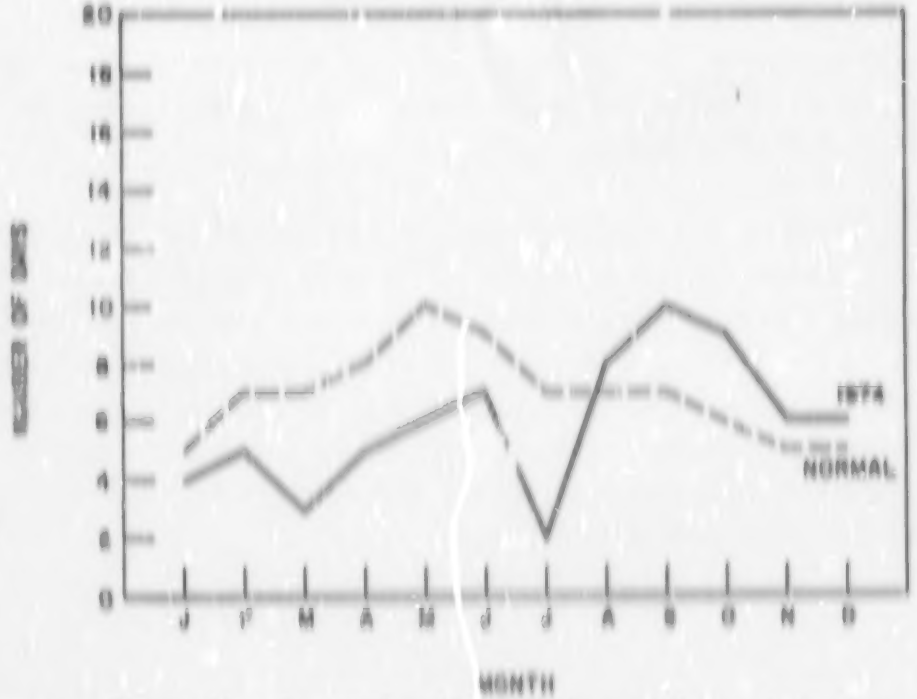



Figure 11. Seasonal pattern of days with precipitation

Unfortunately, no site in Oklahoma City samples every day, so the relationship between particulate levels and precipitation at the day-to-day scale cannot be adequately determined. Thunderstorms are common in the region. There were as many as seven a month during 1974 -- five or more in February, April, May, June, and August -- but again, effects on TSP levels cannot be accurately quantified due to a lack of necessary sampling data. Sampling every 3 or 4 days is inconclusive because there is a varied amount of time between meteorological occurrences and sampling days, and because particulate levels are the result of the combined effect of many factors.

Heating Demand

The number of heating degree days per year in Oklahoma City has been fluctuating fairly evenly over the past 30 years (see Figure 12). The average number of heating degree days is 3,695; in 1974 there were 3,192 heating degree days. Numbers of heating degree days have decreased from 1973 to 1974, as have citywide TSP levels. However, most of the fuel used in Oklahoma City is natural gas, and emissions from fuel usage are a very small percentage of the total, so it is unlikely that TSP levels would reflect heating degree days.

In some urban areas, changes over the years in the pattern of fuel use have resulted in changes in the TSP seasonal pattern. However, in Oklahoma City, no clear seasonal patterns are apparent over the years at the NASN site (Figure 13); what pattern of winter peaks there is before 1968 is the result of the extremely high TSP readings shown. These could be accounted for by infrequent occurrences of high winds and lack of precipitation; data like this was excluded from the air quality data base for the State's Implementation Plan.

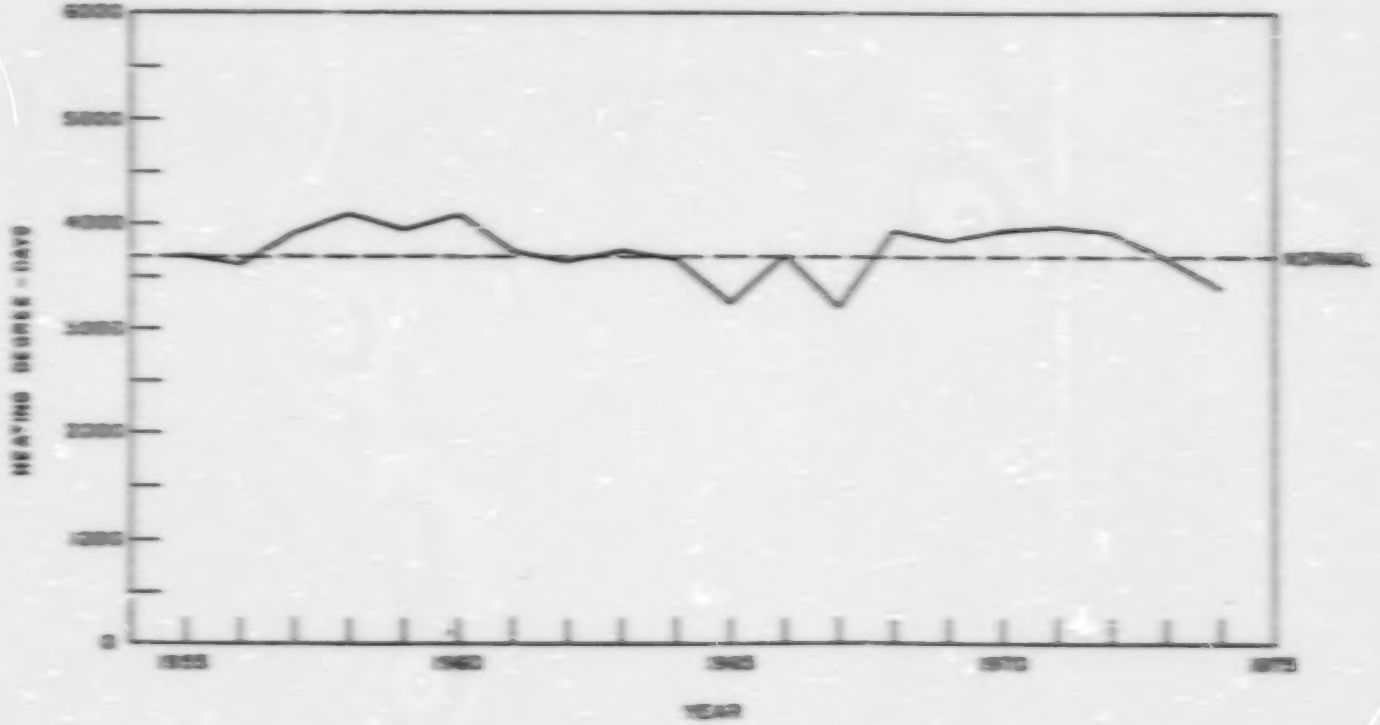


Figure 12. Trend in heating demand

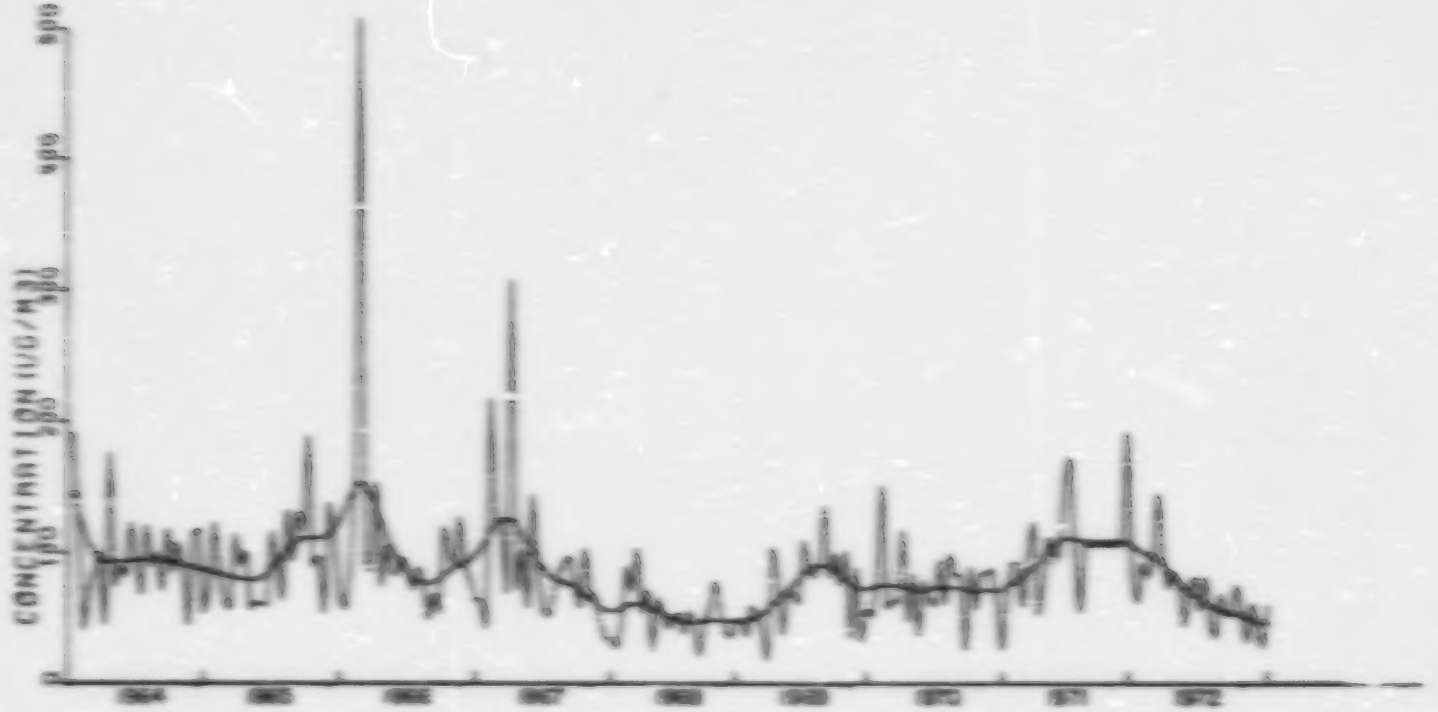



Figure 13. Smoothed seasonal patterns at NASN site

Wind Speed and Direction

Winds in Oklahoma City are predominantly from the north during January and February and from the south-southeast during the remainder of the year. Winds are generally strong, but are calm an average of 3 percent of the time. The seasonal pattern of wind speeds is shown in Figure 14. There is no obvious correlation between wind speed and TSP levels in 1974; the relationship appears direct during the first 5 months of the year, and inverse for the rest of the year. Winds speeds are normally 12.9 mph; in 1974 the average was 11.3 mph. The lowest speeds are typically in the summer, and 1974 was no exception. This is roughly coincident with peak TSP levels in July, but the other TSP concentration peak is in April, which has the highest wind speeds of the year. Hence, it is unlikely that differences in wind speed are an important influence on monthly-scale TSP levels in comparison to other factors. It is very probable, for instance, that the April peak is caused by spring plowing, since April is the beginning of the growing season (in 1974, the last frost was April 5).

Wind directions around Oklahoma City tend to be standard throughout the year (from the north in the winter and from the south-southeast during the rest of the year). On the actual sampling days at the various sites during 1974, winds were from the south-southeast (120 to 190 degrees) on approximately half of the days and from the north (350 to 10 degrees) on about 10 percent of the sampling days. Figure 15 shows the wind direction frequency on days sampled at site 2 (near the airport) as an example. Winds are from the south-southeast at this site on 51 percent of the sampling days, from the north 13 percent of the time, and calm 2.5 percent of the time.

Analyses of average TSP levels versus wind direction were made at a number of sites in Oklahoma City. In general, no overall pattern of

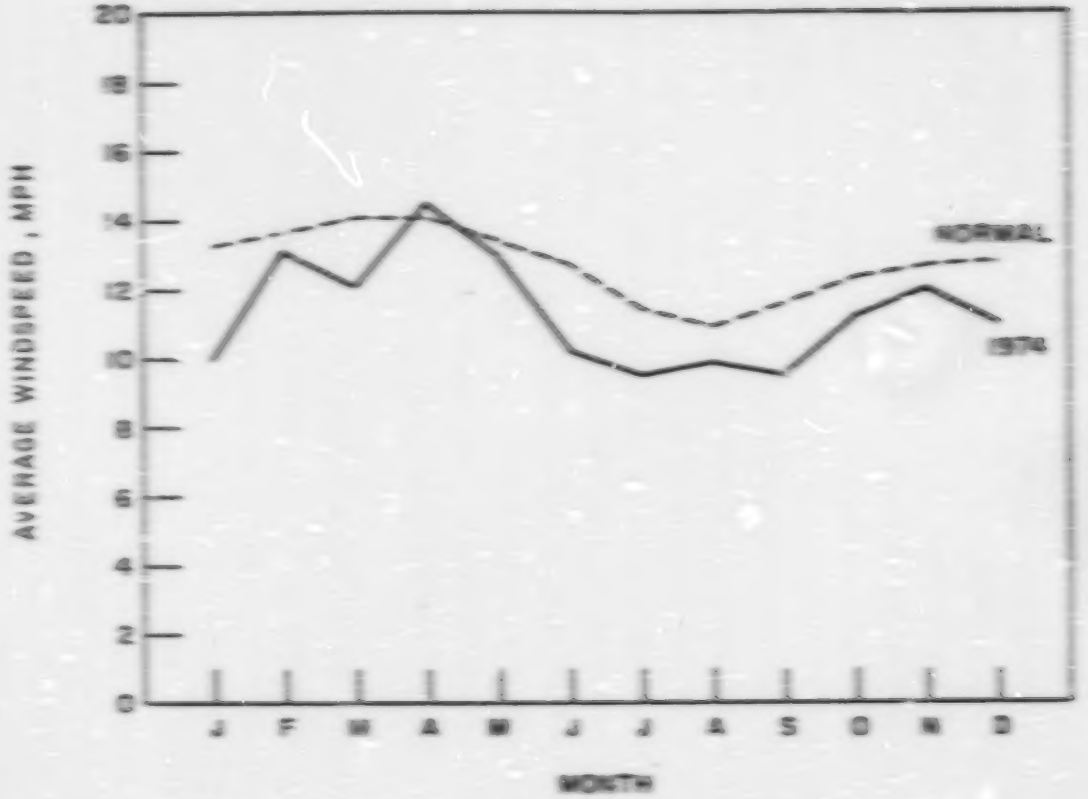



Figure 14. Seasonal pattern of wind speed.

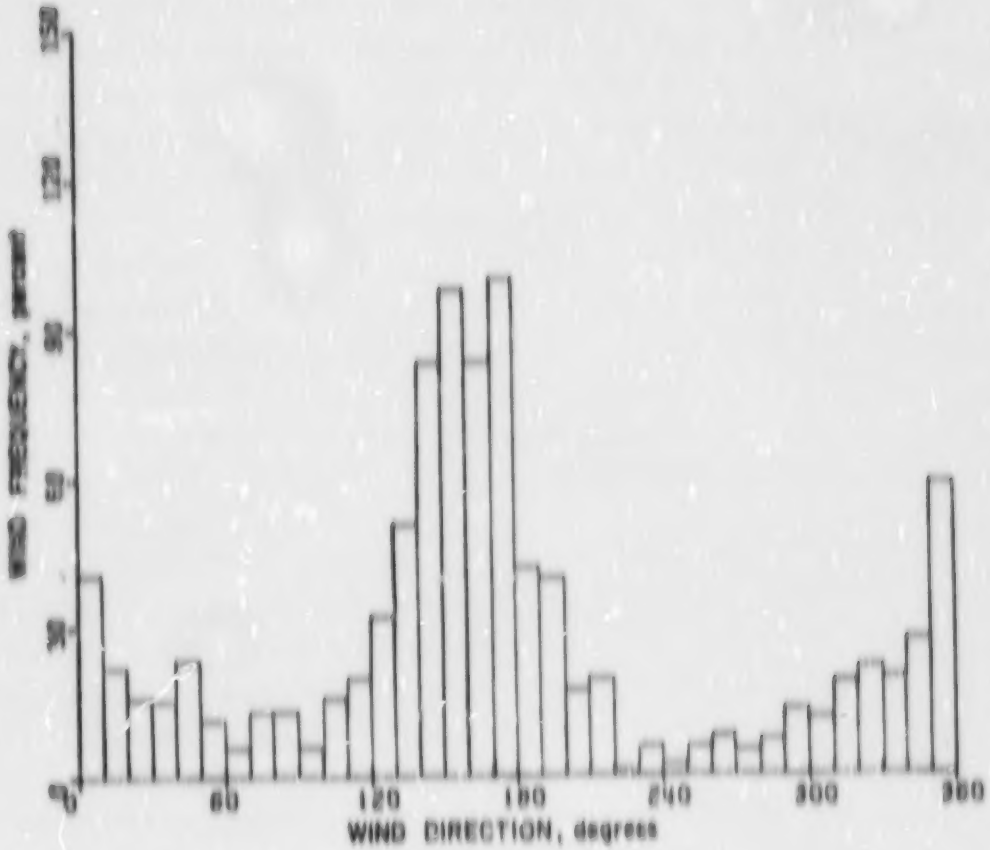



Figure 15. Frequency of wind directions on sampling days at site 2

directional influences were found. There were, however, instances of directional effects at specific sites involving specific local sources; these are discussed subsequently.

## REGULATIONS

The Oklahoma State Department of Health, under the provisions of the Oklahoma Clean Air Act, enforces air pollution control regulations throughout the state. In addition, the Oklahoma City-County Health Department enforces the Air Quality Control Ordinance of Oklahoma City, and identical ordinances adopted by all other municipalities in Oklahoma County. In general, the state and city-county agency staffs are in communication and operate in a cooperative fashion; the selection of enforcement route is based on efficient application or on the relative stringency of the restriction, in the cases where the two sets of regulations differ.

### Summary of Regulations

The Oklahoma State regulations include rules on open burning, motor vehicle control devices, definitions, registration of sources, incineration, fuel-burning equipment, visible emissions, industrial process emissions, fugitive dust, reporting of equipment malfunctions, testing methods, emissions reporting, and permit requirements.

The Oklahoma City regulations contain sections on administration, permit and variance procedures, incineration, fuel burning, industrial processes, fugitive dust, open burning and hot mix asphalt plants. The regulations pertaining to particulate emissions are summarized below.

Open Burning - Under both state and local regulations, open burning in Oklahoma City is banned, although minor exceptions are made (for recreational fires, fire control, and forest and wildlife management). Exceptions are also made for certain agricultural fires and for the disposal

in outlying areas of residential refuse by burning when no alternative method of disposal exists.

Incinerators – New incinerators in Oklahoma City must be multichambered, gas fired in the primary and secondary chambers, and water scrubbed. With the exception of pathological incinerators, they must have a capacity of 75 pounds per hour or greater. The emissions for an incinerator with a capacity greater than 200 pounds per hour are limited to 0.20 grains per dry standard cubic foot. Incinerators with a smaller capacity cannot emit more than 0.30 grains per standard cubic foot.

Visible Emissions – Both the Oklahoma City ordinance and the state regulations prohibit the emission of smoke darker than Number 1 on the Ringelmann chart. The emissions from incinerators can be as dark as Number 2 on the Ringelmann chart for periods not exceeding 5 minutes in any 60 minutes or 20 minutes in any 24 hours. For hot mix asphalt plants, the emissions can be equivalent to Number 3 on the Ringelmann chart for periods not exceeding 4 minutes in any 60 minutes.

Fuel Burning Installations – Both state and local regulations provide an identical allowable emissions restriction; it is plotted in Figure 16 in comparison with the similar limitations in effect in other areas. The city ordinance also provides for roughly equivalent limitations expressed as percent collector efficiency by particle size, and as grain loading per standard cubic foot; the most stringent of the three can be utilized in each instance.

Industrial Process Losses – Both sets of regulations provide an allowable emission rate based on the actual process weight rate; this is plotted in Figure 17 in comparison with other similar regulations.

Fugitive Dust – Oklahoma City's dust regulations are contained in the Process Equipment And hot mix asphalt plant sections and require that

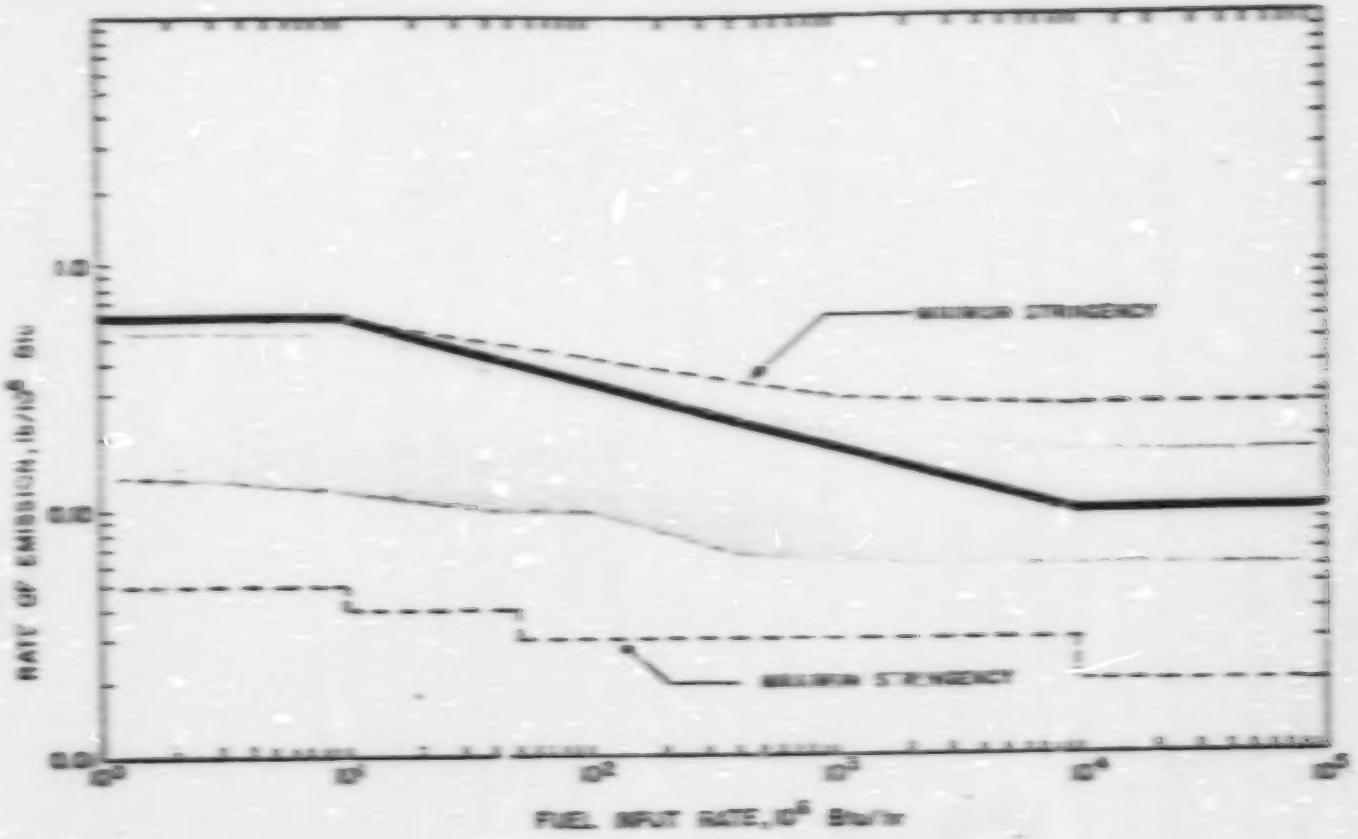



Figure 16. Emission limitations for fuel-burning installations

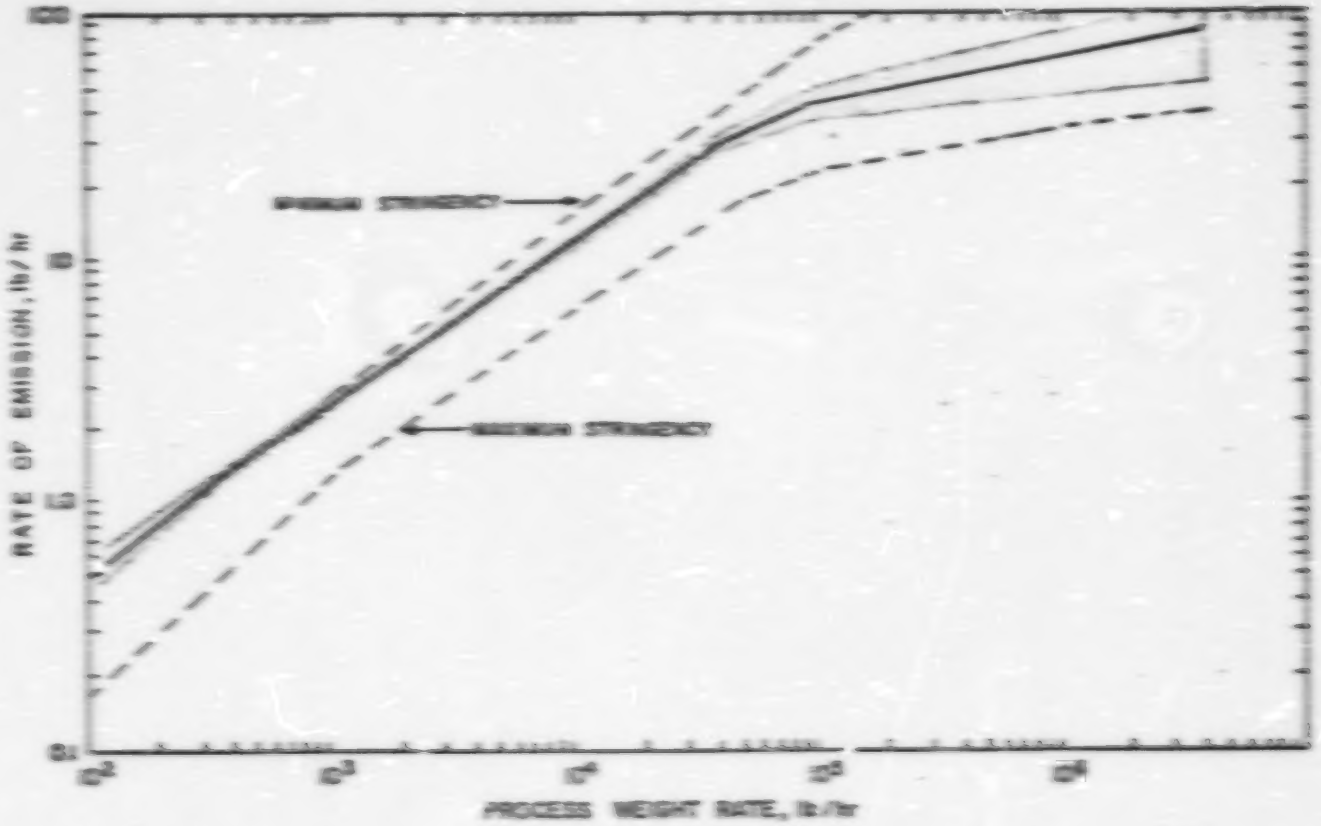



Figure 17. Allowable emissions from industrial process sources

good operating practices be maintained and dust controlled by suitable measures. Hot mix asphalt plants must be equipped with a fugitive dust control system. The state regulations applicable during 1974 merely required "reasonable precautions," but a more extensive regulation has been in preparation.

Regulation Comparison

Of the three types of comparable regulations those applicable in Oklahoma City are generally on the less stringent side. The process weight curve in Figure 17 is about average in stringency in comparison with other cities. The allowable emission rates for fuel burning equipment (Figure 16) are much less stringent than the average, except for sources with greater than 1000 million Btu per hour heat input. The Oklahoma City emission standards for incinerators are among the least stringent of the cities studied.

NETWORK DESIGN AND HI-VOL SITING

As part of the case study in Oklahoma City, field visits were made to 10 of the hi-vol sites. In addition, tabulated information on other sites was assembled. A summary is displayed in Table 8. In general, the network is adequate, with respect to both the overall coverage and design and the placement of individual hi-vols. All types of land use were appropriately covered, with the consideration that there is no heavy industrial area in Oklahoma City. The hi-vols were all generally well-exposed. While the sites on the Municipal Building (No. 1) and Bethany (No. 14) are, at 70 feet and ground level respectively, higher and lower than might be desirable, the majority of sites are at reasonably consistent heights. It would not be expected that the hi-vol network in Oklahoma City would cause any anomalies in proper knowledge of the particulate problem.

Table 6. OKLAHOMA CITY RE-REL SITES

| Added code | Level code no. | City | Address | Site characteristics | Height above ground | Comments/clearance | Est. pop. with 10# |
|---|---|---|---|---|---|---|---|
| 37 [illegible] | 1 | Oklahoma City | 200 N. Miller | C-C | 70 | High office bldg; near w/ac removal | 55 |
| 37 [illegible] | 2 | Oklahoma City | S.W. 44th and Bensac, | B-A | 15 | Airport to west; agriculture to west | 41 |
| 37 [illegible] | 3 | Jones | S.W. Floral and Main | B-A | 14 | Agriculture to south | 75 |
| 37 [illegible] | 4 | Midwest City | 300 Old American | S | 14 | Fire station -- significant driveway fugitive dust | 39 |
| 37 [illegible] | 10 | Midwest City | N.E. 10th and Douglas | S | 14 | Suburban fire station | 49 |
| 37 [illegible] | 14 | Bethany | 3019 N. Rockwell | S | 4 | On grass; construction nearby | 80 |
| 37 [illegible] | 15 | Oklahoma City | 428 N. California | C-C | 15 | Downtown fire station; higher buildings near | 92 |
| 37 [illegible] | 16 | Edmond | 34th & Santa Broadway | S | 15 | | 53 |
| 37 [illegible] | 17 | Oklahoma City | 800 N.E. 13th & Phillips | C-C | 15 | | 89 |
| 37 [illegible] | 18 | Oklahoma City | 23rd N.W., Santa | C-C | 8 | Heavy traffic; stoplight on approach | 98 |
| 37 [illegible] | 19 | Oklahoma City | N.W. Highway & Meridian | S | 15 | Open fields; traffic and stoplight nearer distant | 92 |
| 37 [illegible] | 20 | Oklahoma City | Ranger Station - Beaver Lake | B-A | 15 | | 43 |
| 37 [illegible] | 21 | Oklahoma City | S.E. 74th and Highway | S | 15 | Near expressway | 54 |
| 37 [illegible] | 22 | Oklahoma City | S.W. Second & Robinson | C-C | 15 | Heavy traffic; expressway and ramp | 107 |

## URBAN ACTIVITY

Beyond industrial activity and fuel combustion for various purposes, it is increasingly apparent that in many locations other urban activities, such as routine traffic and construction and demolition activities, are a more major part of urban pollution problems than has been previously recognized. In Oklahoma City, the prominence in the emission inventory of area source categories that are minor in many other areas suggests that these nontraditional sources are quite important there, and in fact, it does appear that major contributions to ambient particulate loadings at several of the monitoring sites are caused by vehicular traffic and construction activities, particularly urban renewal demolition and construction in the center city.

Vehicular traffic produces some direct, "tailpipe," emissions of particulates, and also cause sizable increases in the particulate loading through reentrainment of street dust. In some study areas, the ambient particulate levels at various sites correlate very well with average daily traffic (ADT) levels on the streets adjacent to the sites, if one first adjusts for the slant distance from the street to the hi-vol. A thorough quantitative analysis of this type has not yet been possible in Oklahoma City, for several reasons. At a few sites, current traffic data was not available from the highway department, usually because the adjacent street or streets were not major enough to have traffic monitored frequently. More importantly, at other sites the information on slant distance was inadequate.

Regardless of the lack of a dominant overall relationship, however, it is clear that at several sites the traffic is a significant factor and at one it seems clearly dominant. The center city sites are all recording strikingly high ambient levels and, although some of this is probably due to nearby urban renewal activities, much of the day-in, day-out influence

must necessarily come from the high levels of downtown traffic. Site number 14, to the west of the center city, also exceeds the standards significantly. It is located in a relatively open area, without the dense development and tall buildings characteristic of the CBD, and is removed from the most direct effects of the urban renewal. It is, however, exposed to very high levels of stop-and-go traffic, being located at the intersection of major, dual-roadway, arterials.

The urban renewal activity in the CBD area has also, as noted, had some rather apparent effects on the nearby center city sites. Much of the center city area is involved in a significant demolition and rebuilding effort that has been underway for over 5 years. Three sites (Nos. 1, 15, and 23) are in or immediately adjacent to the project area, although of course actual activity within the area moves about over any period of time. The frequent violations of the short-term standards and the erratic trend behavior of the sites, as well as the overall high ambient levels involved, indicate some significant influence from the activity involved in the project. Attempts are being made through data analysis to quantifiably separate the effects of the urban renewal effort from the effects of other center city activity.

One other site, No. 14 in Bethany, has been clearly influenced by construction activity. The construction of apartment buildings on the property adjacent to the site are believed to have caused increased ambient levels during 1973 and 1974. This is responsible for a striking upward trend over the 3 years 1972 to 1974, and for the departure of the seasonal pattern for the site that was seen in Figure 6.

## IMPLEMENTATION PLANNING PROCEDURE

The State of Oklahoma submitted an implementation plan in January 1972. Certain portions were rejected and more study was done in those areas in 1972 and 1973, using newer data. A review of the entire implementation

plan was completed in December 1974. The Oklahoma State Department of Health's Air Quality Service has responsibility for the SIP, although as noted previously they work closely with the Oklahoma City-County agency.

The Central Oklahoma AQCR was one of two cases used as model regions for air quality planning in the original SIP. The original control strategy for the Oklahoma Clean Air Act was based on maximum 24-hour particulate concentrations of 453 $\mu g/m^3$ in the Central Oklahoma AQCR. This value was subsequently labeled invalid, however, having occurred during a period of high winds and low rainfall; the value was considered to be artificially high due to natural phenomena, and not representative of the normal situation. Air quality data from 24 samplers in Central Oklahoma was then used in the revised implementation plan, with abnormal values not included. Data from the site with the highest annual geometric mean was used in the model; this was site 15, with 8 months of data from April 5 to November 28, 1971, which provided an annual mean of 116.4 $\mu g/m^3$. The background concentration was assumed to be 30 $\mu g/m^3$. The percentages of reduction needed to attain the national standards were then calculated with a standard proportional model:

$$\% \text{ reduction needed} = \frac{A-C}{A-B} \times 100,$$

where:

A is the highest particulate concentration in the area,
B is the background concentration, and
C is the target national standard.

Table 9 summarizes the resulting reductions in emissions necessary to achieve national standard particulate levels in the Central Oklahoma AQCR.

Table 9. PROPORTIONAL MODEL RESULTS

| Sampler $\mu g/m^3$ | Background $\mu g/m^3$ | Air quality standard $\mu g/m^3$ | % reduction required |
|---|---|---|---|
| 116 | 30 | 75 | 48 |
| 116 | 30 | 60 | 65 |

It was calculated that a 48 percent reduction would be necessary to achieve the national primary standard, and a 65 percent reduction would be needed for the secondary standard.

The inventory to which these reductions were to be applied was the inventory in Table 7, totalling 15,399 tons per year of particulate emissions. Of this total, 6,811 TPY were from area sources, including 3,511 from open burning and transportation, and 8,588 TPY were from point sources. Control strategy efforts were directed toward stationary sources and open burning, and no reductions were estimated in tailpipe emissions from transportation.

In the 1976 SIP reevaluation, much of the data base used in the original SIP was reevaluated or newer data was substituted. In the original inventory process sources were responsible for 80 percent of the particulates, and 90 percent of the particulates were from point sources. In the Oklahoma City area there were 34 major point sources, including: five general manufacturing plants; 16 natural gas or natural gas compression plants; three electric power plants; four grain or food processing plants; and eight brick, stone, or asphalt plants. (Emissions from peanut processing were not included, though they amount to 3 percent of the weight of the peanuts processed.) In the new 1976 calculations, 1973 air quality data was used with the proportional rollback model. Background TSP concentrations were assumed to be the same. A new emissions inventory was also used, though it was emphasized that this inventory is an estimation. The resulting emissions tolerance schedule is a regional, not area calculation.

- specifically applicable to parts of the AQCR. Emissions source estimates were based on total particulates, not total suspended particulates and control strategies may have to be adjusted for this.

In summary, the original (January, 1972) Oklahoma implementation plan appeared to be appropriately formulated but, upon review, it was considered desirable to make revisions. The air quality and emissions rates were reexamined, and parts of the plan were criticized and rewritten in the SIP Review of December 1974. This latest revision is felt to be a workable one, and it does have the advantage of later data and more current input on the factors affecting air quality and emissions levels and control strategies. However, any emission-reduction calculation is fundamentally dependent on having a complete estimate of total emissions, so that no plan can be completely satisfactory until good estimates are available for area source emissions, including those from fugitive dust sources, both those within the urban area and those that can be considered natural "dust storms" from more remote rural areas.

## SECTION III

## CONCLUSIONS

Of the five hi-vol monitoring sites at which the primary standard was not achieved in 1974, one is because of exposure to very heavy arterial traffic and one is because of the influence of immediately adjacent building construction. The other three are all located in the center city, and exceed the standard because of both the heavy traffic activity in the area and the impact of a major urban renewal project involving extensive building demolition and reconstruction. It is not clear whether or not these sites would meet the standard in the absence of the urban renewal effect. A fourth CBP site meets the standard because it is located at a relatively high elevation (70 feet) above surface activities.

Most of the other hi-vol sites meet the secondary standard; only one exceeds it slightly. It appears clear that precipitation patterns have an effect on TSP levels, at both an annual and monthly-mean scale. This is probably due to both conventional short-term influences, such as suppression of reentrainment, and longer-term influences on vegetation patterns. Continued maintenance of the ambient standards at these sites is probably dependent on precipitation patterns, and as such, these factors should be quantitatively considered in ongoing air quality planning.

As is generally true, emissions inventory information is inadequate with respect to area sources and particularly fugitive dust sources. Since traditional point sources are not major in the Oklahoma City area, and have been generally well controlled, the lack of good estimates of

emissions from other sources is particularly detrimental to quantitative planning.

Regulations imposed on traditional point sources of emissions are generally moderate or weak in stringency when compared with other urban areas throughout the country. Thus it would probably be technically possible to effect some further emission reductions from such sources. However, considering the relatively small portion of the particulate problem presented by such sources, it seems very unlikely that this would be the most effective way with which to improve particulate air quality. Rather, better knowledge of, and the development of control approaches for the various sources of urban fugitive dust would appear the more productive approach.

## APPENDIX A

## PARTICLE CHARACTERIZATION

For most of the study cities members of the GCA study team acquired hi-vol filters from the 1974 filter banks of the cognizant local agencies. In addition, several filter samples for 1974 and selected earlier years were obtained from state and federal filter banks. Although some filters underwent chemical and/or detailed physical analysis, the principal purpose of obtaining filters was to utilize optical microscopy to identify each of the constituents that comprised more than 5 percent of the particulate mass. The selected filters, which were representative of several different site types and TSP levels within each study area, were returned to a clean room at GCA/Technology Division and carefully inspected for artifacts and evidence of sampler or filter malfunctions.

Each filter was then assigned a randomly generated five digit number which served as the only identifier for the filter sample so that each analyst had no information concerning the city, site, TSP loading or probable local sources associated with the sample. Furthermore, the use of two laboratories for the microscopy, coupled with the randomly generated identifying numbers, permitted a fairly comprehensive quality control program in the form of blind replicate analyses. Since both laboratories utilized more than one analyst, these procedures resulted in as many as four microscopists observing samples from the same filter and, in some cases, the same analyst examining replicate samples from the same filter as many as three times.

The results of this quality control effort, which are presented in Volumes I and II, warn against relying very heavily on the results of any one filter

analysis. However, the random match-up between analyst and filter sample should minimize systematic bias in composited results.

Twenty-seven filters from 11 sites were selected for analysis in Oklahoma City and the meteorological data from the Will Rogers Airport for the selected sampling days are summarized in Table A-1. To gain some insight into the contribution of secondary particulates, much of which is too small to be observed by the microscopists, the annual average sulfate and nitrate concentrations for the NASN site are shown in Table A-2. The results for each of the 23 filters submitted for routine analysis are presented in Table A-3. The results for the filters at each site have been averaged to give a composite of the particulate composition as shown in Table A-4. Three filters underwent replicate analyses, and the results are presented in Table A-5.

The composite particulate characterization for all filters from Oklahoma City that underwent routine analysis, presented in Table A-6, shows that minerals, principally calcite and quartz, overwhelm the suspended particulate material. Oklahoma City ranked highest of the 14 study cities in percent minerals, averaging 68 percent citywide. The only site that showed any substantial deviation from the citywide trend was the Southwest 2nd and Robinson location (No. 22) which also recorded the highest TSP levels of all sites in 1974. That site averaged 72 percent minerals and a high 18 percent rubber. The high rubber values observed are no doubt caused by the heavy vehicular traffic on the nearby expressway and ramp. In fact on the filter from October 11, 1974 rubber particles as long as 500 μm were observed which would indicate a very local source. Oddly, on that same day rubber particles as long as 300 μm were observed on the filter from the 200 North Walker site (No. 1) which is located 70 feet above grade.

The Oklahoma City-County Health Department, Environmental Health Services, Division of Air Quality Control, runs monthly composited analyses for lead

and cadmium at each monitoring site. The monthly and annual values for lead, presented in Table A-7, substantiate the influence of vehicular traffic at some sites. The highest average lead concentration occurred at site 22, where large amounts of rubber were also observed. The second highest lead levels were observed at site 18 which is also suspected of being heavily influenced by traffic.

Table A-1. METEOROLOGICAL DATA ON SELECTED SAMPLING DAYS (WILL ROGERS WORLD AIRPORT, OKLAHOMA CITY)

| Date | Precipitation, in. | | Wind speed, mph | | Wind direction, deg. | |
|---|---|---|---|---|---|---|
| | Day of obs. | Preceding day | Average | Resultant | 3-hour observation | Resultant |
| 9/09/76 | 0 | 0 | 11.0 | 11.0 | 140, 160, 160, 190<br>200, 190, 180, 150 | 160 |
| 9/29/76 | 0 | 0 | 10.3 | 10.3 | 130, 130, 170, 200<br>200, 190, 150, 160 | 180 |
| 7/15/76 | 0 | 0 | 5.0 | 3.8 | 0, 310, 320, 160<br>160, 160, 190, 130 | 140 |
| 10/11/76 | 0 | 0 | 13.3 | 11.0 | 130, 130, 150, 160<br>180, 170, 150, 150 | 161 |
| 10/18/76 | 0 | 0 | 10.3 | 9.8 | 150, 360, 320, 310<br>340, 360, 360, 10 | 350 |
| 10/15/76 | 0 | 0 | 10.0 | 9.8 | 150, 310, 330, 310<br>290, 330, 360, 10 | 321 |

Note: 0 = Calm

Table A-2. ANNUAL AVERAGE CONCENTRATIONS OF SULFATE AND NITRATE IONS AT THE OKLAHOMA CITY, OKLAHOMA, NASN SITE NO. 372200015 ($\mu g/m^3$)

| Year | Sulfate | | Nitrate | |
|---|---|---|---|---|
| | Arithmetic mean | Geometric mean | Arithmetic mean | Geometric mean |
| 1975 | 5.61 | 5.03 | 2.98 | 2.62 |
| 1977 | 4.31[a] | 4.00[a] | 1.78 | 1.48 |
| 1976 | 4.59[a] | 3.33[a] | 2.91 | 1.94 |

[a]Indicates insufficient data for statistically valid year.

Table A-3a. [illegible]

| Item | [illegible] — No. 1 | | | | | | | | | [illegible] — No. 2 | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Date | [illegible] | | | [illegible] | | | [illegible] | | | [illegible] | | | [illegible] | | | [illegible] | | |
| TSP ($\mu g/m^3$) | 42 | | | 72 | | | 46 | | | 39 | | | 38 | | | 51 | | |
| Constituents | Number cols. counted | Size range, $\mu$ | Avg. diam., $\mu$ | Number cols. counted | Size range, $\mu$ | Avg. diam., $\mu$ | Number cols. counted | Size range, $\mu$ | Avg. diam., $\mu$ | Number cols. counted | Size range, $\mu$ | Avg. diam., $\mu$ | Number cols. counted | Size range, $\mu$ | Avg. diam., $\mu$ | Number cols. counted | Size range, $\mu$ | Avg. diam., $\mu$ |
| [illegible] | (0) | | | (0) | | | (0+) | | | (0+) | | | (0+) | | | (0+) | | |
| [illegible] | 1+ | <1-20 | 2 | 1 | <1-100 | 2 | 1 | <1-100 | 1 | 2 | <1-40 | 2 | 4 | <1-40 | 2 | 3+ | <1-40 | 2 |
| [illegible] | 4 | <1-20 | 2 | 3+ | <1-100 | 2 | 2+ | <1-70 | 2 | 3+ | <1-40 | 2 | 3+ | <1-20 | 2 | 1 | <1-40 | 2 |
| [illegible] | 1+ | | | 2+ | | | 1+ | | | | | | | | | | | |
| [illegible] | 1 | <1-20 | 0.5 | 1 | <1-40 | 0.5 | 1+ | <1-20 | 0.5 | 1 | <1-20 | 0.5 | 1+ | <1-40 | 0.5 | 1 | <1-20 | 0.5 |
| Mica | | | | | | | | | | | | | | | | | | |
| [illegible] | (0) | | | (0+) | | | (0) | | | (0) | | | (0+) | | | (0) | | |
| [illegible] | | | | | | | | | | | | | | | | | | |
| Soot: | | | | | | | | | | | | | | | | | | |
| All | 1+ | 3-40 | 0.5 | | | | 1+ | | | 1+ | <1-20 | 0.5 | | | | 1+ | | |
| Coal | 1+ | | | | | | | | | | | | | | | 1+ | | |
| Cotton | | | | | | | | | | | | | | | | | | |
| Fly ash | | | | | | | | | | | | | | | | | | |
| Incinerator | | | | | | | | | | | | | | | | | | |
| Fly ash | | | | | | | | | | | | | | | | | | |
| Vegetable cell | | | | | | | | | | | | | | | | | | |
| Animal cell | | | | | | | | | | | | | | | | | | |
| Vegetable | | | | | | | | | | | | | | | | | | |
| [illegible] | (0+) | | | (0+) | | | (0+) | | | (1+) | | | (0+) | | | (0+) | | |
| [illegible] | | | | | | | | | | | | | | | | | | |
| Pollen | | | | | | | | | | | | | | | | | | |
| Spores | | | | | | | | | | | | | | | | | | |
| Hair | | | | | | | | | | | | | | | | | | |
| Insect | | | | | | | | | | | | | | | | | | |
| Misc. inorganic | | | | | | | | | | | | | | | | | | |
| Cotton | | | | | | | | | | | | | | | | | | |
| [illegible] | (0+) | | | (0+) | | | (1) | | | (0+) | | | (0+) | | | (1+) | | |
| Iron or steel | | | | | | | | | | | | | | | | | | |
| Rubber | | | | 1+ | <1-40 | 10 | 1 | <1-20 | | | | | | | | (1+) | | |

Table A-3b. RESULTS OF FIELD ANALYSES FOR SELECTED SITES IN OKLAHOMA CITY AND VICINITY (NATIONAL – NO. 16 and N.E. 13th AND PHILLIPS – NO. 17)

| Site | National – No. 16 | | | | | | | | | N.E. 13th and Phillips – No. 17 | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Date | 9 May 1974 | | | 25 June 1974 | | | 28 October 1974 | | | 9 May 1974 | | | 29 June 1974 | | | 28 October 1974 | | |
| TSP ($\mu g/m^3$) | 161 | | | 224 | | | 71 | | | 139 | | | 224 | | | 116 | | |
| Components | Number conc., particles | Size range, $\mu m$ | Avg. diam., $\mu m$ | Number conc., particles | Size range, $\mu m$ | Avg. diam., $\mu m$ | Number conc., particles | Size range, $\mu m$ | Avg. diam., $\mu m$ | Number conc., particles | Size range, $\mu m$ | Avg. diam., $\mu m$ | Number conc., particles | Size range, $\mu m$ | Avg. diam., $\mu m$ | Number conc., particles | Size range, $\mu m$ | Avg. diam., $\mu m$ |
| [illegible] | (94) | | | (97) | | | (94) | | | (96) | | | (94) | | | (98) | | |
| [illegible] | 4 | <1-15 | 3 | 6 | <1-15 | 3 | 3 | <1-12 | 2 | 3 | <1-12 | 2 | 2 | <1-11 | 2 | 3 | <1-11 | 2 |
| [illegible] | 3 | <1-12 | 1 | 3 | <1-15 | 2 | 1 | <1-12 | 3 | 1 | <1-12 | 3 | 1 | <1-12 | 3 | 1 | <1-12 | 3 |
| [illegible] | 1 | | | 1 | | | 1 | | | 1 | | | 1 | | | 1 | | |
| [illegible] | 1 | <1-12 | 0.5 | 3 | <1-12 | 0.5 | 1 | <1-12 | 0.5 | 1 | <1-12 | 0.5 | 1 | <1-12 | 0.5 | 1 | <1-12 | 0.5 |
| Mica | | | | | | | | | | | | | | | | | | |
| [illegible] | (1) | | | (3) | | | (1) | | | (1) | | | (1) | | | (2) | | |
| [illegible] | | | | | | | | | | | | | | | | | | |
| Soot: | | | | | | | | | | | | | | | | | | |
| All | 1 | <1-10 | 0.5 | | | | 1 | | | 1 | | | | | | | | |
| Coal | | | | | | | 1 | | | | | | | | | | | |
| Clays: | | | | | | | | | | | | | | | | | | |
| Cl, ash | | | | | | | | | | | | | | | | | | |
| Carbonaceous | | | | | | | | | | | | | | | | | | |
| Cl, ash | | | | | | | | | | | | | | | | | | |
| Mineral, crust | | | | | | | | | | | | | | | | | | |
| Mineral, angular | | | | | | | | | | | | | | | | | | |
| Hydrocarbon | | | | | | | | | | | | | | | | | | |
| Background | (96) | | | (98) | | | (99) | | | (99) | | | (96) | | | (98) | | |
| Materials | | | | | | | | | | | | | | | | | | |
| Fly ash | | | | | | | | | | | | | | | | | | |
| Pollen | | | | | | | | | | | | | | | | | | |
| Fibers | | | | | | | | | | | | | | | | | | |
| Mist, other | | | | | | | | | | | | | | | | | | |
| Clumps | | | | | | | | | | | | | | | | | | |
| Miscellaneous | (3) | | | (2) | | | (1) | | | (1) | | | (3) | | | (2) | | |
| Iron or metal | | | | | | | | | | | | | | | | | | |
| Other | | | | | | | 1 | <1-15 | 11 | | | | | | | | | |

Table A-3c. RESULTS OF FILTER ANALYSES FOR SELECTED SITES IN OKLAHOMA CITY AND VICINITY (2845 N.W. 10th – RT. 10 AND N.W. 122ND ST AND MORTIMER – RT. 10)

| Site | 2845 N.W. 10th – Rt. 10 | | | | | | | | | N.W. Highway and Portico – Rt. 10 | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Date | 9 Mar 1994 | | | 29 June 1994 | | | 30 October 1994 | | | 26 July 1994 | | | 11 October 1994 | | | 26 December 1994 | | |
| TSP (µg/m³) | 67 | | | 200 | | | 122 | | | 83 | | | 49 | | | 48 | | |
| Components | Concentration, ng/sample | Flow Weighted, µg/m³ | Arithmetic, µg/m³ | Concentration, ng/sample | Flow Weighted, µg/m³ | Arithmetic, µg/m³ | Concentration, ng/sample | Flow Weighted, µg/m³ | Arithmetic, µg/m³ | Concentration, ng/sample | Flow Weighted, µg/m³ | Arithmetic, µg/m³ | Concentration, ng/sample | Flow Weighted, µg/m³ | Arithmetic, µg/m³ | Concentration, ng/sample | Flow Weighted, µg/m³ | Arithmetic, µg/m³ |
| [illegible] | (5) | | | (10) | | | (7) | | | (34) | | | (34) | | | (5) | | |
| [illegible] | 2> | <0.100 | 1 | 2> | <0.100 | 1 | 2> | <0.05 | 1 | 1 | <0.05 | 1 | 2> | <0.100 | 1 | 2> | <0.40 | 2 |
| [illegible] | 4 | <0.100 | 1 | 4> | <0.100 | 1 | 2> | <0.05 | 1 | 4 | <0.05 | 1 | 1 | <0.100 | 1 | 5 | <0.40 | 2 |
| [illegible] | | | | | | | | | | | | | 1> | | | 2> | | |
| [illegible] | 1 | <0.05 | 0.5 | 1> | <0.05 | 0.5 | 1> | <0.05 | 0.5 | 2> | <0.05 | 0.5 | 1> | <0.05 | 0.5 | 1 | <0.10 | 0.5 |
| [illegible] | | | | | | | | | | | | | | | | | | |
| [illegible] | (1>) | | | ( 10) | | | (5) | | | (1>) | | | (1) | | | (1) | | |
| [illegible] | | | | | | | | | | | | | | | | | | |
| [illegible] | | | | | | | 2> | | | (1>) | | | 1> | | | 1> | <0.40 | |
| [illegible] | | | | | | | | | | | | | 1> | | | | | |
| [illegible] | | | | | | | | | | | | | | | | | | |
| [illegible] | | | | | | | | | | | | | | | | | | |
| [illegible] | | | | | | | | | | | | | | | | | | |
| [illegible] | | | | | | | | | | | | | | | | | | |
| [illegible] | (20) | | | ( 20) | | | (20) | | | (20) | | | (20) | | | (20) | | |
| [illegible] | | | | | | | | | | | | | | | | | | |
| [illegible] | | | | | | | | | | | | | | | | | | |
| [illegible] | | | | | | | | | | | | | | | | | | |
| [illegible] | | | | | | | | | | | | | | | | | | |
| [illegible] | | | | | | | | | | | | | | | | | | |
| [illegible] | | | | | | | | | | | | | | | | | | |
| [illegible] | (1>) | | | ( 20) | | | (20) | | | (20) | | | 1>) | | | (20) | | |
| [illegible] | | | | | | | | | | | | | 1> | <0.05 | 0 | | | |
| [illegible] | 1> | 1.100 | 40 | | | | | | | | | | | | | | | |

Table A-34. RESULTS OF FILTER ANALYSES FOR SELECTED SIZES IN OKLAHOMA CITY AND VICINITY (S.E. 74th AND 65th – SEL. 22 AND S.W. 2nd AND PORTLAND – SEL. 22)

| Site | S.E. 74th and High – Sel. 22 | | | | | | | | | S.W. 2nd and Portland – Sel. 22 | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Date | 14 July 1976 | | | 21 August 1976 | | | 14 September 1976 | | | 14 July 1976 | | | 21 October 1976 | | | 14 December 1976 | | |
| TSP ($\mu g/m^3$) | 46 | | | 71 | | | 33 | | | 142 | | | 124 | | | 128 | | |
| Components | Number conc., particles | Mass conc., $\mu g$ | Avg. size, $\mu m$ | Number conc., particles | Mass conc., $\mu g$ | Avg. size, $\mu m$ | Number conc., particles | Mass conc., $\mu g$ | Avg. size, $\mu m$ | Number conc., particles | Mass conc., $\mu g$ | Avg. size, $\mu m$ | Number conc., particles | Mass conc., $\mu g$ | Avg. size, $\mu m$ | Number conc., particles | Mass conc., $\mu g$ | Avg. size, $\mu m$ |
| Soil | [illegible] | | | [illegible] | | | [illegible] | | | [illegible] | | | [illegible] | | | [illegible] | | |
| Quartz | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| Calcite | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| Feldspars | [illegible] | | | [illegible] | | | [illegible] | | | [illegible] | | | [illegible] | | | [illegible] | | |
| Hematite | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| Mica | | | | | | | | | | | | | | | | | | |
| Combustion | [illegible] | | | [illegible] | | | [illegible] | | | [illegible] | | | [illegible] | | | [illegible] | | |
| Pollutants | | | | | | | | | | | | | | | | | | |
| Soot | [illegible] | | | | | | [illegible] | | | [illegible] | | | | | | [illegible] | | |
| Oil | | | | | | | | | | | | | | | | | | |
| Coal | | | | | | | | | | | | | | | | | | |
| Cement | | | | | | | | | | | | | | | | | | |
| Fly ash | | | | | | | | | | | | | | | | | | |
| Incinerator | | | | | | | | | | | | | | | | | | |
| Fly ash | | | | | | | | | | | | | | | | | | |
| Burned wood | | | | | | | | | | | | | | | | | | |
| Burned paper | | | | | | | | | | | | | | | | | | |
| Pollutants | | | | | | | | | | | | | | | | | | |
| Mechanical | [illegible] | | | [illegible] | | | [illegible] | | | [illegible] | | | [illegible] | | | [illegible] | | |
| Industrial | | | | | | | | | | | | | | | | | | |
| Silica | | | | | | | | | | | | | | | | | | |
| Gypsum | | | | | | | | | | | | | | | | | | |
| Metal | | | | | | | | | | | | | | | | | | |
| Debris | | | | | | | | | | | | | | | | | | |
| Misc. plant | | | | | | | | | | | | | | | | | | |
| Others | | | | | | | | | | | | | | | | | | |
| Biological | [illegible] | | | [illegible] | | | [illegible] | | | [illegible] | | | [illegible] | | | [illegible] | | |
| Pollen or spore | | | | | | | | | | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| Other | | | | | | | | | | | | | | | | | | |

Table A-3a. RESULTS OF FILTER ANALYSES FOR SELECTED SITES IN OKLAHOMA CITY AND VICINITY (JONES – NO. 5, N.E. 10th AND DOUGLAS – NO. 10, AND 428 W. CALIFORNIA – NO. 15)

| Site | Jones – No. 5 | | | N.E. 10th and Douglas – No. 10 | | | 428 W. California No. 15 | | |
|---|---|---|---|---|---|---|---|---|---|
| Date | 29 June 1975 | | | 29 June 1975 | | | 29 June 1975 | | |
| TSP ($\mu g/m^3$) | 51 | | | 110 | | | 217 | | |
| Component | Quantity, tenths | Size range, $\mu$ | Avg. size, $\mu$ | Quantity, tenths | Size range, $\mu$ | Avg. size, $\mu$ | Quantity, tenths | Size range, $\mu$ | Avg. size, $\mu$ |
| **Fluorals** | (10) | | | (90) | | | (80) | | |
| Quartz | 6 | <1-100 | 4 | 14 | <1-70 | 4 | 50 | <1-200 | 3 |
| Calcite | 2+ | <1-150 | 4 | 7 | <1-70 | 4 | 30 | <1-300 | 3 |
| Feldspars | 1+ | | | | | | | | |
| Hematite | 1 | <1-30 | 0.5 | 4 | <1-30 | 0.5 | | | |
| Mica | | | | | | | | | |
| **Combustion Products** | ( 00) | | | (1+) | | | (1+) | | |
| Soot: | | | | | | | | | |
| Oil | | | | 1+ | | | | | |
| Coal | | | | | | | | | |
| Glassy fly ash | | | | | | | | | |
| Incinerator fly ash | | | | | | | | | |
| Burned wood | | | | | | | | | |
| Burned paper | | | | | | | | | |
| Magnetite | | | | | | | | | |
| **Biological Material** | ( 00) | | | (00) | | | (00) | | |
| Cotton | | | | | | | | | |
| Spores | | | | | | | | | |
| Pollen | | | | | | | | | |
| Starch | | | | | | | | | |
| Misc. plant tissue | | | | | | | | | |
| **Miscellaneous** | ( 00) | | | (00) | | | (00) | | |
| Iron or steel | | | | | | | | | |
| Rubber | | | | | | | | | |

TABLE A-4a. COMPOSITE SUMMARY OF FILTER ANALYSES FOR SELECTED SITES IN HEARING CITY AND VICINITY

| Site | [illegible] No. 1 | [illegible] No. 2 | [illegible] No. 3 | [illegible] No. 4 | [illegible] No. 5 | [illegible] No. 6 |
|---|---|---|---|---|---|---|
| No. of filters | 3 | 3 | 3 | 3 | 3 | 3 |
| | Quantity, percent | Quantity, percent | Quantity, per cent | Quantity, percent | Quantity, percent | Quantity, percent |
| Constituent | Average / Range | Average / Range | Average / Range | Average / Range | Average / Range | Average / Range |
| [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| Constituents [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| [illegible] | | | | | | |
| [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| [illegible] | | | | | | |
| [illegible] | | | | | | |
| [illegible] | | | | | | |
| [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| [illegible] | | | | | | |
| [illegible] | | | | | | |
| [illegible] | | | | | | |
| [illegible] | | | | | | |
| [illegible] | | | | | | |
| [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |

Table 3-45. [illegible]

| Site | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
|---|---|---|---|---|---|---|---|
| No. of Cases | 3 | | 3 | | 2 | 2 | 3 |
| | [illegible] | | [illegible] | | [illegible] | [illegible] | [illegible] |
| Components | Average | Range | Average | Range | – | – | – |
| [illegible] | (51) | (5–95) | (77) | (57–97) | (76) | (96) | (93) |
| [illegible] | 31 | (5–62) | 11 | (3–22) | 10 | 3 | 5 |
| [illegible] | 12 | (2–22) | 4 | (1–10) | 11 | 78 | 38 |
| [illegible] | 4 | 4 | 1 | (1–1) | 1 | 1 | 1 |
| [illegible] | 12 | (3–21) | 11 | (1–21) | 12 | 4 | 3 |
| [illegible] | | | | | | | <1 |
| [illegible] | (19) | (4–31) | (13) | (4–22) | (12) | (4) | (13) |
| [illegible] | | | | | | | |
| [illegible] | | | | | | | |
| [illegible] | 1 | (1–2) | 1 | (1–2) | 1 | 1 | 1 |
| [illegible] | 1 | (1–1) | 1 | (1–1) | <1 | <1 | 1 |
| [illegible] | <1 | (1–1) | 1 | (1–1) | <1 | <1 | 1 |
| [illegible] | | | <1 | (1–1) | | <1 | <1 |
| [illegible] | | | <1 | | | | |
| [illegible] | | | <1 | | | | <1 |
| [illegible] | | | | | | | |
| [illegible] | (11) | | (12) | (10–13) | (11) | (11) | (10) |
| [illegible] | | | | | | | |
| [illegible] | <1 | | <1 | | <1 | <1 | <1 |
| [illegible] | <1 | | <1 | | <1 | <1 | <1 |
| [illegible] | <1 | | <1 | (1–1) | <1 | <1 | <1 |
| [illegible] | <1 | | <1 | (1–1) | <1 | <1 | <1 |
| [illegible] | | | | | | | |
| [illegible] | (11) | | (9) | (7–10) | (11) | (11) | (11) |
| [illegible] | <1 | | <1 | | <1 | <1 | <1 |
| [illegible] | <1 | | 9 | (7–10) | | | |

Table A-5. RESULTS OF REPLICATE ANALYSES OF OKLAHOMA CITY FILTERS

| Site | Bethany - No. 4 | | | | 428 W. Gatty, No. 14 | | |
|---|---|---|---|---|---|---|---|
| Date | 29 June 1975 | | 18 Oct. 1975 | | 29 June 1976 | | |
| TSP ($\mu g/m^3$) | 238 | | 73 | | 237 | | |
| Laboratory | A | B | A | B | A | A | B |
| Analysis | 1 | 1 | 1 | 1 | 1 | 2 | 1 |
| Components | | | | | | | |
| Minerals | (99) | (36) | (86) | (33) | (93) | (86) | (57) |
| Quartz | 63 | | 13 | | 55 | 28 | |
| Calcite | 15 | | 60 | | 35 | 59 | |
| Feldspars | 6 | | 8 | | 3 | | |
| Hematite | 15 | | 5 | | | 6 | |
| Mica | | | | | <1 | <1 | |
| Combustion Products | ( 1) | (64) | (10) | (53) | ( 7) | (10) | (28) |
| Soot: | | | | | | | |
| Oil | 1 | | 4 | | 1 | | |
| Coal | <1 | 1 | 1 | 6 | 1 | | 6 |
| Unidenti-fied soot | | | | | | 2 | |
| Coal fly ash | | | | | | 5 | |
| Class F fly ash | <1 | | 3 | | 1 | 1 | |
| Incinerator fly ash | | 63 | <1 | 47 | <1 | | 23 |
| Burned wood | | | | | | | |
| Burned paper | | | | | <1 | | |
| Magnetite | | | | | | | |
| Biological Material | (<1) | (<1) | (<1) | (16) | (<1) | ( 1) | ( 9) |
| Pollen | | | <1 | | <1 | <1 | |
| Spores | <1 | | <1 | | <1 | <1 | |
| Paper | | | <1 | | <1 | <1 | |
| Starch | | | | | <1 | | |
| Misc. plant tissue | <1 | | <1 | | <1 | 1 | |
| Miscellaneous | (<1) | (<1) | ( 0) | (<1) | (<1) | ( 1) | ( 1) |
| Iron or steel | <1 | | <1 | | <1 | | |
| Rubber | | | 0 | | | 1 | |

Table A-6. CITYWIDE COMPOSITE SUMMARY OF FILTER ANALYSES IN OKLAHOMA CITY

| No. of Cities | 27 | |
|---|---|---|
| | Quantity, percent | |
| Components | Average | Range |
| Minerals | (88) | 61-99 |
| Quartz | 29 | 10-65 |
| Calcite | 45 | 15-75 |
| Feldspars | 3 | <1-6 |
| Hematite | 11 | 0-30 |
| Mica | <1 | |
| Other | | |
| Combustion Products | ( 8) | 1-31 |
| Soot: | | |
| Oil | 5 | 1-25 |
| Coal | 2 | <1-6 |
| Misc. soot | | |
| Glassy fly ash | 1 | 0-3 |
| Incinerator fly ash | <1 | |
| Burned wood | <1 | |
| Burned paper | <1 | |
| Magnetite | | |
| Carbon black | | |
| Other | | |
| Biological Material | (<1) | <1-6 |
| Pollen | <1 | |
| Spores | <1 | <1-2 |
| Paper | <1 | |
| Starch | <1 | 0-1 |
| Misc. plant tissue | <1 | <1-2 |
| Leaf trichomes | | |
| Miscellaneous | ( 4) | <1-30 |
| Iron or steel | <1 | |
| Rubber | 4 | 0-30 |
| Other | | |

Table A-7. MONTHLY AND ANNUAL LEAD CONCENTRATIONS FROM HI-VOL FILTERS IN OKLAHOMA CITY, OKLAHOMA FOR 1974, $\mu g/m^3$

| Site No. | Jan. | Feb. | Mar. | Apr. | May | June | July | Aug. | Sep. | Oct. | Nov. | Dec. | Annual arithmetic mean |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1.41 | 1.34 | 0.67 | 0.43 | 0.62 | 0.61 | 0.78 | 0.47 | 0.45 | 1.16 | 0.42 | 0.46 | 0.72 |
| 2 | 0.33 | 0.17 | 0.13 | 0.12 | 0.17 | 0.14 | 0.12 | 0.11 | 0.14 | 0.15 | 0.07 | 0.11 | 0.18 |
| 5 | 0.34 | 0.13 | 0.10 | 0.10 | 0.14 | 0.12 | 0.14 | 0.07 | 0.21 | 0.27 | 0.13 | 0.17 | 0.17 |
| 6 | 0.83 | 0.47 | 0.40 | 0.52 | 0.34 | 0.39 | 0.52 | 0.39 | 0.65 | 0.39 | 0.38 | 0.36 | 0.47 |
| 10 | 0.87 | 0.46 | 0.45 | 0.61 | 0.26 | 0.38 | 0.75 | 0.47 | 0.49 | 0.44 | 0.42 | 0.43 | 0.50 |
| 14 | 0.94 | 0.29 | 0.40 | 0.34 | 0.28 | 0.41 | 0.54 | 0.39 | 0.65 | 0.37 | 0.25 | 0.30 | 0.44 |
| 15 | 2.21 | 2.21 | 0.95 | 1.49 | 0.92 | 1.11 | 1.37 | 1.68 | 1.77 | 1.08 | 1.91 | 2.84 | 1.40 |
| 16 | 2.38 | 0.52 | 0.32 | 0.41 | 0.40 | 0.48 | 0.49 | 0.48 | 0.51 | 0.51 | 0.27 | 0.26 | 0.69 |
| 17 | 0.48 | 0.51 | 0.39 | 0.44 | 0.31 | 0.39 | 0.53 | 0.39 | 0.62 | 0.34 | 0.56 | 0.43 | 0.45 |
| 18 | 0.94 | 1.43 | 1.47 | 1.78 | 1.23 | 1.40 | 1.67 | 1.34 | 1.92 | 1.94 | 1.28 | 1.20 | 1.50 |
| 19 | 1.19 | 0.86 | 0.45 | 0.61 | 0.38 | 0.53 | 0.87 | 0.78 | 0.67 | 0.74 | 0.32 | 0.35 | 0.66 |
| 20 | 0.19 | 0.19 | 0.11 | 0.12 | 0.11 | 0.13 | 0.15 | 0.12 | 0.11 | 0.27 | 0.12 | 0.14 | 0.15 |
| 21 | 0.58 | 0.57 | 0.29 | 0.29 | 0.29 | 0.29 | 0.46 | 0.30 | 0.26 | 0.53 | 0.35 | 0.31 | 0.38 |
| 22 | 2.13 | 1.82 | 1.67 | 1.59 | 1.02 | 1.22 | 1.63 | 1.61 | 1.79 | 2.36 | 0.86 | 0.98 | 1.54 |